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THE QUARTERLY BULLETIN

The Quarterly Bulletin of the Michigan Agricultural Experiment Station is issued in February, May, August and November. It presents progress reports on long-term major research projects and final reports on short-term projects.

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THE QUARTERLY BULLETIN

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MICHIGAN STATE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION
EAST LANSING

L. M. TURK, DIRECTOR
R. E. MARSHALL, ASSISTANT DIRECTOR
M. T. ALLEN, EDITOR

MICHIGAN BROILER TEST No. 2
Fall 1955[1]

By J. A. DAVIDSON, W. N. FISCHER, H. C. ZINDEL and C. M. McCRARY
DEPARTMENT OF POULTRY HUSBANDRY AND KELLOGG DEMONSTRATION FARM

PURPOSE OF TEST

THIS WAS A DESCRIPTIVE TEST of strains and strain crosses under environment and management conditions at the Michigan State University Kellogg Farm, Hickory Corners, Michigan.

CONDITIONS OF TEST

The test was conducted in the two-story brooder house on the M. S. U. Kellogg Farm at Hickory Corners. Birds were entered on September 28, 1955. One hundred and four chicks (52 pullets and 52 cockerels) were required for an entry (Table 1). Each entry was placed in a pen of equal floor space (approximately 1 square foot per bird) which had been drawn by lot from the two floors. This was the only variable other than the chicks. Each chick was wing-banded for identification and to draw a sample for the slaughtering data.

Chicks were confined to a small area by a tight corral for 2 days and heat was supplied by a heat lamp. They were fed from a small feeder placed on paper. The paper was removed the second day. Large feeders were substituted for smaller feeders as the chicks grew. All feeders were the same type for each pen. Mason jar fountains were used at first. They were replaced by small fountains which served until the chicks were large enough to use automatic waterers. Peanut shells added at intervals as needed were used for litter.

Toward the end of the 10 weeks the use of lamps was discontinued during the day when temperatures were high enough to prevent bunching. The lamps were used at night throughout the test.

[1]Sponsored by the Michigan State Poultry Improvement Association, East Lansing, Michigan.

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TABLE 1—Entrants and breeding groups

Entry no.	Breeder	Male	Female
34	Arbee Poultry Farm	Arbee Red Cornish	New Hampshire
36	DeWitt's Zeeland Hatchery	X 100	White Rock
30	Fairview Hatcheries	Fairview Barred Rock	White Rock
28	Fairview Hatcheries	Fairview Vantress Dom. White	Fairview Barred Rock
29	Fairview Hatcheries	Fairview Vantress Dom. White	Exp. Cross
35	W. S. Hannah & Sons	White Rock	White Rock
31	Hess' St. Louis Hatchery	Vantress Dom. Wh.	White Rock
25	Holtzapple W. R. Farm	Dom. White Cornish	White Rock
23	Holtzapple W. R. Farm	White Nick	White Nick
24	Holtzapple W. R. Farm	White Rock	White Rock
39	Klager Hatcheries	Silver Broads	White Rock
37	Klager Hatcheries	White Rock	White Rock
38	Klager Hatcheries	New Hampshire	New Hampshire
33	Lambright Hatchery	White Meateor Cross	White Meateor Cross
32	Lambright Hatchery	White Meateor Cross	White Rock
27	Osborne's Breeding Farm	Osborne's Jumbo White Rock	White Rock
26	Rainbow Trail Hatchery	White Rock	White Rock
40	Tice's Barred Rock Farm	Barred Rock	Barred Rock

DISEASE CONTROL

A coccidiostat in the feed was used at recommended levels throughout the test. At 4 weeks of age the chicks were vaccinated by the dust method[2] for infectious bronchitis and Newcastle disease under the direction of Dr. S. C. Schmittle M.S.U. poultry pathologist. Some CRD-like symptoms (chronic respiratory disease) appeared between the sixth and seventh week. It apparently was widespread and affected some pens more than others; there was very little mortality due to the disease, but it undoubtedly affected feeding efficiency to some extent (Table 2).

WEIGHING AND SCORING

At 4 and 7 weeks each entry was group-weighed and the following information was obtained for the information of the breeder or hatchery: average live weight, feed consumed, and number in each pen.

[2]Vaccines supplied through the courtesy of Lederle Laboratories, division of American Cyanamid Company.

TABLE 2—Feed conversion and mortality—10 weeks

Entry no.	Mortality	Pounds of chicken per 100 lbs. feed	Feed per lbs. chicken	Number	
				Males	Females
	(percent)	(lbs.)	(lbs.)		
34	3.6	34.06	2.94	57	50
36	4.95	34.67	2.88	41	55
30	1.94	32.41	3.09	54	47
28	2.88	32.43	3.08	51	50
29	1.94	32.62	3.07	44	57
35	.96	32.1	3.11	58	45
31	.96	33.21	3.01	46	57
25	3.81	37.38	2.68	44	57
23	....	33.55	2.98	49	55
24	2.88	32.71	3.06	49	52
39*	4.81	33.16	3.02	41	58
37*	5.77	27.4	3.65	38	60
38*	.96	32.56	3.07	54	49
33	2.88	31.16	3.21	48	53
32	.96	34.03	2.94	48	55
27	3.77	32.43	3.08	55	47
26	.96	32.94	3.04	51	52
40*	4.76	29.4	3.4	45	55
Average	2.71	32.68	3.07	..	..

*Chicks were hatched 1 to 2 days later than other entrants.

At 7 weeks, feathering was observed and individual birds were checked for identity.

At 10 weeks of age, the birds were individually weighed, checked for sex, and a random sample of 10 of each sex taken for slaughtering (Table 3). The samples were mixed in a pen where they remained overnight. They were loaded the next morning—20 in a crate—and transported to the Hamilton Farm Bureau, Hamilton, Michigan. There live weights were taken as they were hung on the dressing line, dressed weights were recorded, and the birds were scored, eviscerated, and the eviscerated weights recorded (Tables 4 and 5).

TABLE 3—Live weight and variability of each sex—10 weeks, entire group

Entry number	Males		Females	
	Average weight	Variability*	Average weight	Variability*
	(lbs.)		(lbs.)	
34	3.87	7.1	3.09	7.0
36	3.72	7.0	2.99	9.3
30	3.25	11.2	2.67	9.6
28	3.75	8.2	2.82	10.7
29	3.53	11.1	2.79	7.8
35	3.22	12.5	2.64	11.9
31	3.70	11.3	2.89	9.6
25	3.75	7.3	3.13	9.6
23	3.43	8.2	2.81	9.2
24	3.28	11.2	2.56	10.7
39†	3.34	9.3	2.65	11.4
37†	2.87	8.9	2.33	14.3
38†	3.24	10.9	2.47	9.6
33	3.12	11.2	2.52	10.4
32	3.61	8.3	2.91	8.9
27	3.31	11.2	2.66	8.8
26	3.18	10.9	2.63	7.6
40†	2.99	9.6	2.52	8.8
Average	3.40	....	2.73	....

*Expressed as coefficient of variation. A low numerical value of the coefficient shows greater uniformity.
†Chicks were hatched 1 to 2 days later than other entrants.

TABLE 4—Live, dressed and eviscerated weights of sample and carcass yields—10 weeks

Entry number	AVERAGE WEIGHTS						CARCASS YIELDS			
	Live		Dressed		Eviscerated		Dressed		Eviscerated	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(percent of live weight)			
34	3.96	3.14	3.63	2.8	2.93	2.34	91.67	89.17	74.02	74.43
36	3.65	2.69	3.26	2.4	2.58	1.93	89.32	89.22	70.71	71.78
30	3.31	2.64	2.97	2.39	2.42	1.89	89.73	90.53	73.26	71.70
28	3.67	2.86	3.3	2.43	2.69	2.0	89.92	84.97	73.22	69.93
29	3.59	2.77	3.22	2.47	2.63	2.02	89.69	89.17	73.29	73.1
35	3.19	2.73	2.94	2.38	2.34	1.94	92.16	87.18	73.26	71.17
31	3.66	2.87	3.37	2.62	2.62	2.04	92.08	91.29	71.72	71.18
25	3.35	2.77	3.01	2.49	2.43	2.03	89.85	89.89	72.57	73.10
23	3.27	2.75	2.91	2.52	2.32	1.99	88.99	91.64	70.89	72.47
24	3.03	2.55	2.72	2.28	2.23	1.83	89.77	89.41	73.43	71.57
39*	3.14	2.48	2.86	2.13	2.35	1.71	91.08	85.89	74.84	68.79
37*	2.86	2.35	2.63	2.25	1.97	1.64	91.96	95.74	68.81	69.66
38*	3.37	2.46	2.98	2.22	2.36	1.75	88.43	90.24	70.09	71.14
33	2.99	2.44	2.76	2.15	2.18	1.63	92.31	88.11	72.94	66.60
32	3.46	2.8	3.14	2.52	2.54	2.04	90.75	90.00	73.32	72.75
27	3.33	2.57	3.00	2.26	2.41	1.85	90.09	87.94	72.25	71.98
26	3.21	2.56	2.88	2.16	2.3	1.73	89.72	84.38	71.65	67.62
40*	3.07	2.42	2.85	2.22	2.29	1.81	92.83	91.74	74.50	67.15
Average	3.34	2.66	3.02	2.37	2.42	1.89	90.58	89.25	72.49	70.90

*Chicks were hatched 1 to 2 days later than other entrants.

*TABLE 5—Dressed scores of sample—10 weeks**

Entry number	CARCASS GRADE†										Percent grade A
	Fleshing		Feathering		Fat		Conformation		Defects ‡		
	M	F	M	F	M	F	M	F	M	F	
34	1.1	1.1	1.2	1.3	1.3	1.2	1.1	1.1	0	0	90
36	1.4	1.6	1.1	1.1	1.3	1.4	1.3	1.5	2	2	75
30	1.5	1.5	1.6	1.7	1.3	1.3	1.4	1.6	2	2	25
28	1.3	1.3	1.2	1.2	1.3	1.3	1.2	1.3	2	0	85
29	1.2	1.3	1.4	1.2	1.3	1.3	1.2	1.3	2	4	75
35	1.4	1.3	1.8	1.3	1.4	1.2	1.4	1.3	0	0	100
31	1.4	1.4	1.1	1.2	1.4	1.4	1.4	1.3	8	2	75
25	1.4	1.4	1.2	1.1	1.2	1.2	1.4	1.4	2	2	85
23	1.3	1.4	1.1	1.2	1.3	1.3	1.3	1.4	0	2	85
24	1.5	1.6	1.5	1.2	1.5	1.7	1.5	1.7	0	0	20
39§	1.4	1.5	1.2	1.8	1.4	1.6	1.4	1.5	2	4	40
37§	1.5	1.7	1.4	1.5	1.6	1.7	1.6	1.7	2	4	35
38§	1.4	1.5	1.3	1.6	1.2	1.4	1.5	1.5	2	2	55
33	1.5	1.4	1.4	1.4	1.5	1.4	1.4	1.5	2	6	60
32	1.2	1.1	1.1	1.2	1.2	1.3	1.2	1.2	0	0	95
27	1.5	1.5	1.1	1.2	1.3	1.4	1.5	1.7	0	0	70
26	1.5	1.6	1.4	1.4	1.5	1.6	1.4	1.6	0	2	45
40§	1.6	1.4	2.2	1.7	1.8	1.6	1.5	1.4	2	4	30
Average	1.4	1.4	1.3	1.4	1.4	1.4	1.4	1.4	1.6	2	..

*The authors wish to express appreciation to Professor J. M. Moore, poultry extension specialist; and Hans Haugard, district marketing agent, for scoring and grading the dressed birds.

†Dressed score: 1, 2, 3, 4, 5. Based on federal standards of quality—average score shown.

‡Defects: Includes breast blisters, crooked and dented breast bones, crooked backs, etc.

§Chicks were hatched 1 to 2 days later than other entrants.

FEED

The chicks were fed the following starting ration for the first 7 weeks:

Ground yellow corn	1,103	lbs.
Pulverized oats	100	lbs.
Soybean oil meal (44 percent)	500	lbs.
Fishmeal (60 percent)	100	lbs.
Alfalfa meal (17 percent)	60	lbs.
Dried whey	35	lbs.
Dried brewers' yeast	35	lbs.
Ground limestone	30	lbs.
Dicalcium phosphate	25	lbs.
Iodized salt	5	lbs.
Choline chloride (25 percent dry mixture)	2½	lbs.
Vitamin premix (145,000 I units D; 330 I.U. Vitamin E, 200,000 U.S.P. units Vitamin A per lb.)	2	lbs.
Nicarbazin (Merck Premix .0125 percent)	1	lb.
Pro-Gen (Abbott Laboratories)	1	lb.
Manganese sulfate (feeding grade)	½	lb.
Diphenyl-F-phenylene-diamine (Bowman Feed Products)	¼	lb.
Niacin	18	grams
Procaine penicillin	2	grams

At 8 weeks, a finishing mash was substituted for the starter by increasing the corn 100 pounds, reducing the soybean oil meal by 200 pounds, adding 100 pounds of corn gluten meal, and substituting 50 pounds of meat and bone scraps for 50 pounds of the fish meal.

LIMITATIONS

Results from such small samples should not be interpreted from the viewpoint of competition among entrants.

Relatively little reliance should be placed on information from one test, It will require repeated testing before the real performance of strains and strain crosses can be evaluated reliably. This attitude, it is hoped, will be expressed by the entrants in using these data for other than their own information. A winner cannot be picked because of the problem of evaluating fairly the various characteristics which were observed.

COST OF RAISING PULLETS ON SEVEN MICHIGAN FARMS

By C. C. HOYT[1] and L. E. DAWSON[2]

THE POULTRY INDUSTRY in the United States has become a major source of farm income. In 1953, farmers received a gross income of more than 4 billion dollars from poultry and poultry products.[3] During this same period Michigan farmers received a gross income in excess of $94,500,000 from poultry and poultry products. Eggs contributed over two-thirds of this total, and chickens (other than broilers) accounted for another one-fifth. Thus, according to the Michigan Agricultural Statistics, returns from egg production enterprise actually accounted for between 85 and 90 percent of the total poultry income in Michigan.

Michigan farmers must decide each year whether or not to replace a majority of hens in their laying flocks. Sixty-six percent of the total number of hens on farms January 1, 1954, were classed as pullets and 29 percent as hens.[4] The remaining 5 percent were not classified.

The purpose of this study was to determine and evaluate the factors affecting the costs of growing replacement pullets on typical Michigan poultry farms.

PROCEDURE

Seven Michigan poultry farm operators cooperated in this study by keeping accurate records of the costs and returns on their flock replacement enterprises.[5] These farms were located in the counties of Kalkaska, Lapeer and Livingston, and two farms each in Ingham and Tuscola.

Replacement flocks varied in size from 70 to 1,709 pullets. Three flocks consisted of Single Comb White Leghorns, three flocks con-

[1]Short Course Department.
[2]Poultry Husbandry Department.
[3]Borum, C. J. (1955). Michigan agricultural statistics, 1954. Mich. Dept. Agr., Lansing. 40 pp.
[4]Ibid.
[5]Appreciation is expressed to each farm operator who supplied records for this analysis.

ARTICLE 38-51

sisted of White Plymouth Rocks, and one was a flock of New Hampshires.

Pullet chicks were purchased by five of the cooperators; straight-run chicks by another, and started pullets by the other.

Each cooperator was visited during the spring of 1954 and given a copy of the Baby Chick Record.[6] Procedures for recording all essential information were outlined.

When the pullets had attained an age of 24 weeks, the records were obtained and summarized. Each record was handled as a case study, since the number of cooperators was limited.

RESULTS and DISCUSSION

TOTAL COSTS

The total rearing costs on these farms ranged from $1.95 to $4.16 per pullet. Net cost (total cost minus value of products sold) varied

TABLE 1—Expense, income and net cost in rearing pullets to 24 weeks: seven Michigan farms, 1954

Item	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6	Farm 7
Charges (dollars per pullet raised)							
Chicks	.571	.554	.791	.376	.292	.274	.400
Feed	1.810	.953	1.607	2.160	1.291	1.669	1.241
Labor	1.160	.221	1.064	.771	1.168	1.123	.301
Fuel and lights	.248	.082	.038	.126	.018	.089	.039
Building and equipment	.108	.034	.185	.429	.262	.075	.097
Miscellaneous	.068	.014	.049	.118	.010	.010	.055
Overhead*	.198	.093	.187	.199	.152	.162	.107
Total charges	4.163	1.951	3.921	4.179	3.193	3.402	2.240
Credits (dollars per pullet raised)							
Sale of eggs, meat	.072	.049	.047	.861	.004	.093	.216
Home use	.015	.014	.204	.710	.....	.079	.019
Other	.012	....	....	.143	....	.134	.027
Total credits	.099	.063	.251	1.714	....	.306	.262
Net cost	4.064	1.888	3.670	2.465	3.189	3.096	1.978

*Overhead charges at 5 percent of all charges.

[6]Mimeographed record form prepared by members of the Michigan State University Agricultural Economics Department.

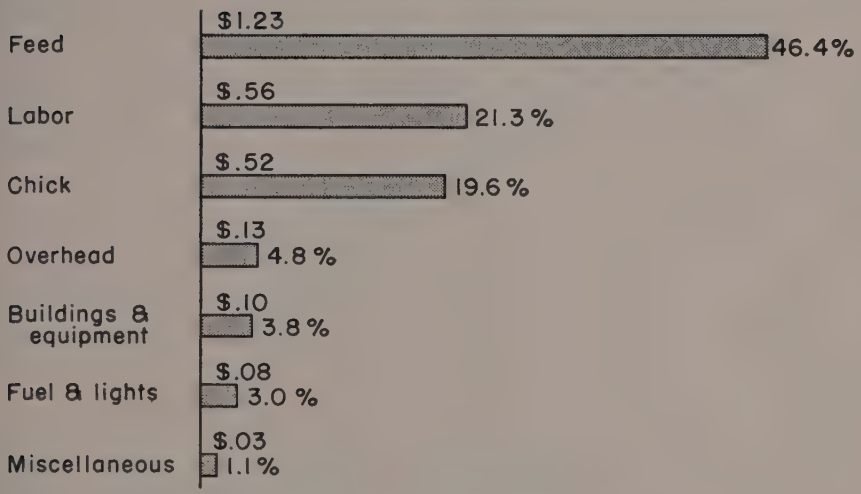

Fig. 1. Average pullet cost, seven Michigan farms, 1954.

from $1.89 to $4.06. A summary of production costs is shown in Table 1.

Many factors affected the cost of rearing pullets. Among the more important were feeding efficiency, labor efficiency, mortality and initial chick cost. On these farms the cost of feed represented 46.4 percent of the total cost (Fig. 1). Labor cost was second (21.3 percent) and chick cost was third (19.6 percent). These three factors accounted for 87.3 percent of the total cost of rearing pullets and were very similar to those reported by Wright.[7]

FEED COST

Cost of feed represented 46.4 percent of total costs of raising replacement pullets on these seven farms. Feed consumption ranged from 25.0 to 45.9 pounds per pullet raised (Fig. 2). Feed cost ranged from $0.95 to $2.16 per pullet raised. The higher feed cost was for straight-run chicks, however, and does not offer a direct comparison. The highest feed cost for sexed pullets was $1.81 per pullet raised.

Both the high and low feed costs were for sexed White Leghorn pullets. This was due largely to the high mortality in the flock which consumed the most feed per pullet and reflected a high cost per bird surviving.

[7]Wright, K. T. (1938). Profitable poultry management. Mich. Agr. Expt. Sta. Spec. Bul. 294. 52 pp.

TABLE 2—Influence of mortality on pullet cost, seven Michigan farms, 1954

Item	Farm 4	Farm 2	Farm 5	Farm 7	Farm 6	Farm 3	Farm 1
Number chicks started.....	156	1872	400	530	203	500	451
Number pullets housed.....	70	1709	370	375	179	392	242
Hatching date (1954).....	1-26	2-4	1-26	1-26	3-14	4-8	1-4
Chick cost (dollars).....	.376	.554	.292	.400	.274	.791	.571
Mortality 1st 12 weeks (%) ..	.6	4.2	6.0	9.0	3.9	14.0	44.8
Mortality 2nd 12 weeks (%)..	1.3	1.8	1.5	1.1	9.8	7.6	1.5
Total mortality (%).....	1.9	6.0	7.5	10.1	13.7	21.6	46.3
Net cost per pullet raised (dollars).....	2.47	1.89	3.19	1.98	3.10	3.67	4.06

MORTALITY

The results of this study show that flock mortality has a direct influence on pullet cost. Although the lowest mortality rate did not result in the lowest cost pullet, those flocks with lower than average mortalities produced pullets for lower than average cost. Table 2 shows that mortality ranged from 1.9 percent to 46.3 percent of the chicks started. Several factors contributed to these death losses. The most apparent contributing factor, however, was inadequate floor space per chicks. A respiratory infection present in two flocks contributed to the losses.

Although not considered as mortality, the percentage of culls removed before the pullets were housed affected the cost per pullet housed. On one farm, an outbreak of bronchitis in the non-vaccinated birds resulted in a high culling rate. In another flock, overcrowding appeared to be the stress factor.

CHICK COST

Although chick costs represented 19.6 percent of the total costs of producing pullets in this study it did not necessarily follow that

TABLE 3—Relationship between flock size and labor efficiency.

	Pullets housed		
	0-300	301-600	over 600
Number of farms.....	3	3	1
Average number pullets housed..	164	397	1709
Labor cost.....	$1.02	$.84	$.22

lower priced chicks produced lower cost pullets. Wright[8] (1938), in a study of Michigan farm flocks found that chick cost constituted 21 percent of the total cost of rearing pullets. He found that the chick cost factor was exceeded only by feed cost. In this study, chick cost ranked third in importance and was lower than feed and labor costs.

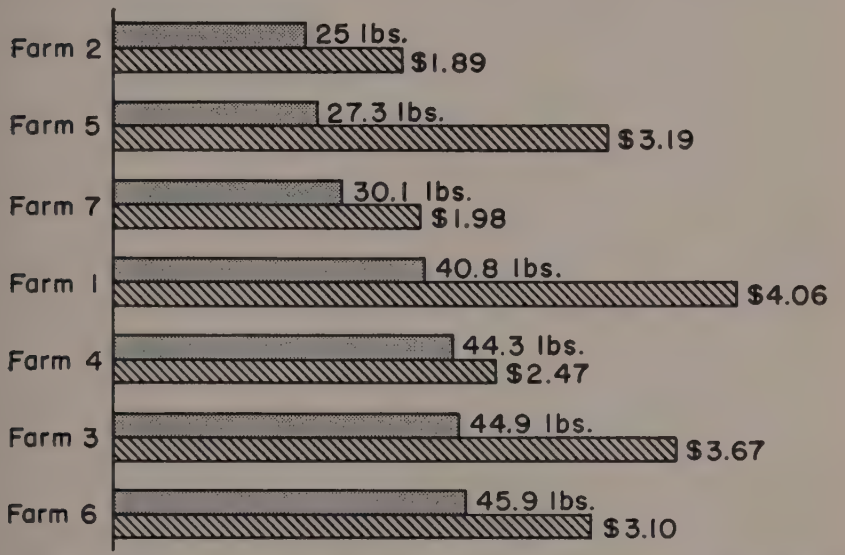

Fig. 2. Relationship between pounds of feed consumed and total cost per pullet, seven Michigan farms, 1954.

BREED

The cost of raising pullets to maturity varies materially between light and heavy breeds. As shown in Table 3, sexed pullets of the light breeds were raised the most economically; straight-run heavy breed pullets were intermediate in cost of rearing; and sexed heavy breed pullets were the most expensive to rear.

It was observed that management affected costs more than did breed and variety differencs. Although the most economical production was found in a flock of Single Comb White Leghorn sexed pullets, the least economical production also occurred in a flock of Single Comb White Leghorns.

[8]Ibid.

LABOR EFFICIENCY

Labor cost ranged from $0.22 to $1.17 per pullet housed. The major contributing factor affecting this variation was the number of pullets raised. Flocks with less than 300 pullets raised had an average labor cost of $1.02, while those from 301 to 600 pullets had an average labor cost of $0.84; the largest flock (1,709 pullets) had a labor cost of only $0.22.

SUMMARY AND INTERPRETATIONS

Detailed expense and income data were obtained from seven Michigan poultry farm operators. The poultry flocks raised by these operators varied in size from 70 pullets to over 1,700 pullets at housing time.

The cost of feed for raising these pullets represented over 46 percent of the total production cost on these farms. Feed consumed or wasted per pullet raised ranged from 25 pounds on one farm to 46 pounds on another farm. Feeding skills which contributed to the lower number of pounds of feed used per pullet on one farm could have reduced this range for feed utilization if practiced on all farms. By attending to some of the details, such as supplying more feeders or more feeder space, by keeping feeders elevated to a proper level for the chicks, or by filling the feeders only partially full; feed wastage and total feed used may have been reduced.

The mortality varied from 1.9 percent on the farm with the lowest death loss to 46.3 percent on the farm with the highest loss. It appears that overcrowding and respiratory troubles contributed most to the high mortality rates. Careful attention in providing room for the chicks and the practice of vaccinating the birds for some respiratory diseases in areas where recommended might have reduced this large mortality on some farms.

The cost per chick purchased varied from $.29 to $.79. Although the original cost affected the cost of pullets raised somewhat, it was belived that the dollars-and-cents cost was not a true measure of the value of the pullets raised. From a genetic evaluation, superior stock was probably obtained by the purchase of higher priced chicks.

Considerable differences were noted in the rearing costs between the heavy breed chicks and the light breed chicks. It was concluded, however, that use of recommended rearing skills by the manager affected the cost more than did breed and variety differences. Al-

though the most economical production was found in a flock of Single Comb White Leghorns, so also was the least economical production found in a flock of the same breed and variety.

Labor cost varied from $.22 to $1.17 per pullet housed. Flock size, along with improved practices and skills by the manager, appeared to have the most influence on reducing labor cost.

The total cost of rearing the pullets on these farms varied from $1.95 to $4.16 per pullet housed. After deducting the value of products sold during the first 24 weeks, the net rearing cost per pullet varied from $1.89 to $4.06.

These higher costs could undoubtedly have been reduced by following the approved rearing practices and by putting into use some of the recommended skills which result in lower mortality, less feed used per pullet housed, less labor required per pullet housed, and higher than average quality of pullet housed.

ATTITUDES OF MICHIGAN FARMERS TOWARD CONTROL PROGRAMS

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IN THE SUMMER OF 1953, farmers voted for marketing controls on wheat. This meant that acreage allotments were to be vigorously enforced. Penalties were to be assessed against all farmers exceeding allotments, if the allotment were larger than 15 acres. This was the first time since the war that marketing controls were applied to Michigan farmers. Previously to 1953, acreage allotments had been in effect, but farmers were able to exceed the allotment if they were willing to forego the privilege of using the existing price support program by way of commodity loans and storage.

Most Michigan farmers interviewed in the summer of 1954 expected that allotments would continue. Only a little over half expected to comply with individual acreage allotments. However, marketing quotas brought a much higher response because of the substantial penalties involved. With respect to acreage allotments, farmers with intensive livestock operations indicated that they were less likely to comply than were crop farmers or those with small livestock enterprises. However, many farmers had not yet adjusted their thinking and their operations to the program of marketing quotas and cash penalties. In fact, over a third of the farmers did not believe that penalties for excess wheat would be applied when the wheat was fed to livestock.

These statements are based on interviews with over 400 farmers in four different types of farming areas in southern Michigan. These farmers represent differing farm situations, and face various crop and livestock alternatives as they adjust to smaller wheat acreages. The areas and sampling method were described in a previous article.[1]

[1]Hathaway, Dale (1955). The effects on agricultural production controls in 1954 on four Michigan farming areas. Mich. Agr. Expt. Sta. Quart. Bul. 37: 565-573.

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While not representative of all Michigan agriculture, these farmers were wheat growers, had received wheat allotments, and were making choices among major alternatives typical of the decision situations facing Michigan wheat farmers in 1954. Many of the questions asked were related to actions and adjustments made by farmers in their individual crop or livestock operations.

This report, however, is concerned primarily with the relations of the attitudes of farmers towards production control programs, and certain personal characteristics and type of farming operations.

LIVESTOCK FARMERS LESS LIKELY TO COMPLY WITH ACREAGE ALLOTMENTS

Farmers were asked what effects continuing acreage allotments would have on their farming operations. About 30 percent felt that little or no changes would be necessary. Acreage allotments did not include any penalty provisions; hence many farmers believed that they could ignore them if a large cut in acreage were required. They would lose the right to use the price support program but would otherwise be unaffected.

However, farmers with large farms (over 180 acres in cropland) were more likely to expect that continued acreage allotments would require changes. More of these farmers would sell substantial parts of their crops rather than use them for livestock production; hence, the price support program was an important alternative to the open market. Similarly, farmers under 55 years of age expected the allotments to have more effect than did older farmers.

Both of these differences come into play if cash crop farmers are compared with intensive dairy farmers. The former tend to be younger and to have larger farms, while the latter tend toward older operators running smaller farms. In any case, the farmers with large dairy enterprises relative to the size of their farm expected the allotment program to have less effect on their farms than did those farmers without livestock. The dairy farmers probably felt that they could not switch any more land to hay and pasture, since they needed most of the present crop acreages to supply feed for their dairy animals.

Farmers next were asked whether they would comply with acreage allotment on individual crops and whether they would comply with a total acreage allotment (cross-compliance). Forty-six percent of the farmers indicated that they would comply with an individual crop

allotment; 41 percent said they would not; and 13 percent were undecided.

However, as shown in Table 1, there was an increase in the willingness to comply as livestock became a less important part of the farm business. The first group was significantly different from the rest. Intensive dairy farmers are much less likely to have crops to sell than are any of the other three groups.

TABLE 1—Farmers' expected compliance with acreage allotments as related to type of farm

Reaction to controls	Intensive livestock %	Extensive livestock %	Less than 5 animal units %	No livestock %
Will comply	46	57	61	62
Will not comply	54	43	39	38
Total	100	100	100	100
Number of respondents	190	70	22	69

Somewhat more farmers indicated an unwillingness to comply with a total farm allotment. Again there was a gradual and more marked increase in expected participation as livestock decreased in importance. Similarly, farmers with larger acreages and somewhat less intensive livestock enterprises were more willing to comply. It is also of interest that farmers who attended meetings held by the county agent were more likely to comply than those who did not. In part, at least, this seems to be because more operators of larger farms went to these meetings. It is also possible that the impact of the program and their major interest in agriculture led them to attend the meetings in an effort to find a better way to operate with controls.

The major reason given for complying with either individual or total farm allotments was given as "to get the program benefits," reported by 32 percent of those responding. Other important responses were that they "would comply if the enforced changes were minor," or because they felt that they "had to comply." Among those not expecting to comply, over 30 percent said that "they needed the crops for feed"; and about 20 percent more said that "they did not plan on using any of the program benefits."

FARMERS' ATTITUDES TOWARD MARKETING QUOTAS

In effect, marketing quotas were a form of acreage allotment, but the impact of each was quite different. Acreage allotments could be ignored by farmers willing to lose eligibility for price supports. However, market quotas were accompanied by heavy fines on producers who exceeded their allotments. Farmers, who may have been rather indifferent to acreage allotments because they could do as they saw fit, were more likely to think twice when faced with a penalty on excess acreage. Two considerations were selected for study: What were the farmers' beliefs with regard to enforcement by penalty? What were the participation rates and attitudes in the voting on quotas in 1953 and 1954?

The majority of the farmers believed the penalty of about $1.12 per bushel on excess acreage would be enforced for wheat sold off the farm. As shown in Table 2, 70 percent believed that it would be enforced. Approximately one-fourth of the farmers based their reasoning on earlier cases when the penalty had been enforced; another third reasoned that it would probably be enforced as part of a law.

TABLE 2—Farmers' opinions on the wheat penalty enforcement in terms of wheat use

Penalty enforcement	Wheat for market %	Wheat for feed %
Will be enforced	70	36
Will not be enforced	13	37
Undecided	17	27
Total	100	100
Number of respondents	414	414

Many farmers did not expect that the penalty would be enforced on wheat used for feed; in fact opinion was evenly divided. The number who were undecided was also larger. Among those not expecting the penalty to be enforced, the reason most frequently given was "it will be imposible to enforce such a law." There were no relationships between these attitudes and the importance of the livestock enterprise. In fact, the only relationship noted was that farmers with 5 to 20 years of experience (and comparable groups in terms of age of operator) were less likely to expect the penalty to be enforced than were farmers with either more than 20 or less than 5 years of experience.

The beliefs described above may have been sufficiently strong to lessen the interest in voting in the 1953, 1954 and 1955 wheat marketing quota vote. Despite their compulsory effect if passed, only 4 out of 10 farmers interviewed took part in the voting. About 1 out of 10 was ineligible because his wheat acreage had been cut to 15 acres. Among those voting and willing to report their vote, the attitudes were less favorable to marketing quotas than to acreage allotments. Between 1953 and 1954, the sentiment turned sharply against marketing quotas. But by 1955, as indicated in the statewide vote, opinion had again swung back to being slightly favorable to quotas. Table 3 shows a comparison of these votes.

TABLE 3—The sample and state vote on wheat quotas in indicated years

How Michigan farmers voted	Sample		State		
	1953 %	1954 %	1953 %	1954 %	1955 %
For quotas	64	47	73	45	51
Against quotas	36	53	27	55	49
Number voting	157	141	11,174	8,305	8,016

The change in the number of farmers who voted for and against quotas in 1953 and 1954 was not caused by individual farmers changing the way they voted. Rather, the change suggests that different farmers went to the polls in 1954 than had gone in 1953. Only about two-thirds of the farmers in the study who voted for quotas in 1953 voted again in 1954; whereas nine-tenths of the farmers who were against marketing restrictions in 1953 voted again in 1954.

Nearly 9 out of 10 farmers who stayed away from the polls in 1953 but voted in 1954 were against quotas. Farmers who were against marketing quotas apparently were firm in their attitudes and expressed their disapproval by taking part in the balloting. The farmers who favored marketing quotas were not so definite in their opinions and did not express their views when the time came to vote.

Although comparisons were made by type of farm, size of farm, age of the operator, attendance at county agent meetings, membership in each of the various farm organizations and tenure status, no relationships were found. Only the experience of the operators appeared to be related to voting attitudes. Farmers with 10 to 20 years of experience were much more likely to vote "no" than farmers with more ex-

perience or less experience. Otherwise, the attitudes as revealed by voting apparently were randomly distributed among this group of farmers.

This was not the case, however, with respect to participation in the election. There was a very definite increase in participation as the farm increased in size, as shown in Table 4. Three times as many farmers with 300 acres or more voted as did farmers with less than 100 acres. While they apparently felt that the vote was important to them, their votes were distributed in about the same ratios as other farmers.

Since more of the farmers with large farms attended county agent meetings, it was also noted that attendance at such meetings was associated with a higher participation in the voting process. Whether attendance at the meetings led to participation in the voting process, or whether the size of the farm led to participation in both meetings and elections, is not clear. It may be that all three characteristics are part of the behavior patterns of farmers who are more successful and have a large volume of business.

TABLE 4—Farmers' participation in the 1954 quota vote as related to farm size in acres

Voting status in 1954	Acres						
	0–99	100–139	140–179	180–219	220–259	260–299	300–over
Voted	19	38	34	40	43	50	57
Did not vote	81	62	66	60	57	50	43
Total	100	100	100	100	100	100	100
Number of respondents	34	39	56	50	44	24	75

FARMERS' ATTITUDES TOWARD PRICE SUPPORT LEVELS

Some farm products were being supported at 90 percent of parity in 1954; others at levels down to 75 percent; while others were not supported. The number of farm products receiving price supports had declined since 1948. Farmers were asked a number of questions about price support levels and parity. As might be expected, many farmers seemed to feel that all supported commodities should be supported at the same percentage of parity. This was far from a unanimous opinion, however; 19 percent did not think they should be, and one-fourth did

not express an opinion. Actually, only 56 percent of the farmers answered in favor of equality of treatment. It is of interest that landowners appeared to favor equal treatment more heavily than did tenants, with part-owners in an intermediate position.

Of more interest in Michigan is a question which asked whether the farmer thought all prices were being supported at the same level. About two-thirds of the farmers asked knew that not all supported commodities were supported at the same percentage of parity. When asked what products were less favorably treated, the large majority listed (correctly) dairy products. Nearly three-fourths of the dairy farmers listed dairy products as being less favorably treated; while only 40 percent of the other farmers put dairy products in this category.

The reduction in support levels on dairy products as a result of the accumulation of large supplies of butter, cheese and dried milk was widely publicized in 1954. Yet these responses are evidence that retention of this knowledge was at much lower levels for farmers not directly involved. Less than half as many farmers (42 percent) were able to identify a product which they thought was supported at relatively too high a level. Wheat was listed most frequently.

FARMERS' KNOWLEDGE ABOUT AND ATTITUDES TOWARD THE STORAGE PROGRAM VERSUS THE DIRECT PAYMENT PLAN

A number of prominent argricultural economists have long advocated federal price programs that would operate by making payments directly to farmers when the price falls below a guaranteed level. Such a program would be a substitute for purchases in the market and storage or special sales programs, all basic to present price support programs. Payments to dairy farmers late in World War II and the present wool program embody the direct payment idea. The plan proposed by former Secretary Brannan also incorporated this idea.

The principles of both methods were presented to the farmers, with specific reference to perishables. They were asked if they were familiar with the programs and then to evaluate them. The same question was asked in both 1950 and 1954.[2]

Between 1950 and 1954, the attitudes of Michigan farmers appeared to have shifted somewhat in favor of direct payments and away

[2]For a report on the 1950 study, see: Hathaway, Dale; Everett Peterson and Lawrence Witt (1952). Michigan farmers and the price support program. II. Farmers' attitude toward the support program. Mich. Agr. Expt. Stat. Tech. Bul. 235. 40 pp.

from the storage and surplus diversion program. Fewer farmers were able to list advantages for the storage and diversion program for perishable products. The decline in farm product prices since 1950 despite the operation of the federal price support program probably is a major reason for farmers being less sure of its desirability. In 1950, 40 percent of the farmers gave advantages for the diversion program, compared with 21 percent in 1954.

In the 1950 study exactly half of the farmers interviewed had not heard of the direct payment method. By 1954, this number had dropped to 39 percent. Of perhaps more interest is the indication in Table 5 that the direct payment plan was considered similar to some parts of the Brannan Plan by only 1 percent of the respondents, compared with 14 percent in the earlier study. While the association probably would have been higher in both periods if the question were worded for direct recall, these responses certainly indicate that the association of the two ideas is less important today.

TABLE 5—The familiarity of farmers with the direct payment plan as shown by the 1950 and 1954 surveys

Knowledge of direct payments	1950 Survey %	1954 Survey %
Had heard of the direct payment idea	33	40
It is part of the Brannan Plan	14	1
Heard of it during World War II	..	11
Total that had heard of direct payments	47	52
Had never heard of direct payments	50	39
Didn't know if had heard of direct payments	2	6
No answer	1	3
Total	100	100
Number of respondents	500	414

Farmers who attended county agent meetings and farmers who belonged to a farm organization were more likely to be familiar with the direct payment idea than were other farmers. A greater percentage of farmers having more than five units of livestock had heard about direct payments than those with less than five units or no livestock at all. Part of this difference could be accounted for by the intensive dairy operators, 15 percent of whom had had experience with such

payments on milk or cream during World War II. Nearly half of the farmers with less than 10 years of farming experience had not heard of direct payments, whereas only one-third of the farmers with more than 10 years of farming experience had not heard of direct payments. Again, this could be related to the fact that a greater number of farmers with over 10 years of farming had come in contact with direct payments on milk and cream during the war.

Approximately 6 out of 10 farmers saw no advantages for direct payments, responded "don't know," or gave no answer at all. This compares with 8 out of 10 farmers who gave similar answers about the storage program. The largest group of farmers who listed advantages said direct payments would lower food costs to consumers and thus increase consumption. Others said there would be no loss to the government from storage and waste, and that farm prices would be raised to the farmers. Some felt that the advantage of direct payments would be the elimination of the processor's participation in the support benefits.

There was very little difference between the advantages given in 1950 and those given in 1954. There were no relationships noted between advantages given and any of the characteristic groups, such as age, tenure status, membership in farm organization, and percent of income received from farming.

About 10 percent of the farmers could see no disadvantages to direct payments. There were an additional 48 percent who had no opinions or did not answer the question; this is contrasted with 40 percent who had no opinion or didn't comment on disadvantages of the storage program. Of those farmers who gave disadvantages, the main disadvantage was "the high cost to government" which was given by one-tenth of the farmers. Approximately 5 percent of the farmers were concerned about becoming too dependent on government policies or else didn't like the idea of a government handout. Other farmers believed that the program would be difficult and costly to administer, result in a lot of red tape, and involve waiting long periods of time for their money from the government.

Finally, the farmers were asked to choose between the two types of programs. Their response is indicated in Table 6. There appears to have been a sharp shift away from the diversion—storage methods which were in use in 1954 and an increase in those favoring direct payments. To the extent that the two samples can be compared (and the lack of geographical differences within the sample suggests that

they can), the data suggest that some farmers are looking with more favor upon new techniques. The price decline since 1951 and the inability of present programs to maintain farm income is leading farmers to look for new approaches. The increase in "don't know" answers suggests the same idea. At the same time, the comments reported in the two paragraphs above indicate that farmers generally do not have a clear-cut concept of the nature, advantages and disadvantages of the two programs (and probably other alternative techniques).

TABLE 6—Farmers' choice as to methods of supporting perishable products as shown by the 1950 and 1954 surveys

Method of supports preferred	1950 Number Survey	1954 Survey
Diversion methods used at present	34	21
Direct payments to farmers	32	39
Didn't know	22	30
Didn't want either one	10	7
No answer	2	3
Number of respondents	500	414

SUMMARY

The information presented in this report indicates that many farmers knew the provisions of the existing farm programs and had developed specific views with regard to the program. Some of these attitudes were closely related to the characteristics of their farm enterprises. Thus, livestock farmers who needed feed tended to be noncompliers on acreage allotments. Crop farmers with large acreages were more willing to comply and to accept the need for allotments.

Many farmers had not reconciled themselves to the penalty provisions on excess wheat acreage, particularly if the wheat were used for livestock feed. In this case, and with most other attitude questions, there tended to be few relations between attitudes, personal characteristics and type of farm.

Individual farmers had very definite and specific views on one or another farm program. Yet there were many farmers with imperfect knowledge and no clear-cut attitudes. A slight majority did not participate in the elections on wheat marketing quotas. Those who did seemed to be more fully involved in and committed to farming. The

limited knowledge of the details of the programs is also indicated by the small percentage of non-dairy farmers who realized that dairy supports were lower than those for grains. The high percentage of dairy farmers with this information suggests that, if and as programs increase their impact on individual farm welfare, information will be more widespread.

Nonetheless, as decisions are made in a properly functioning democratic society, effort must be given to reducing the number of people who are poorly informed, or who do not participate in the processes created to obtain group decisions. At the same time, it is probably desirable to guard against too many elections involving detailed decisions which could lead to decisions being made only by an extremely interested minority.

Farmers' attitudes toward the methods of implementing price policies appear to be shifting. The experience of declining prices from 1951 to 1954 has led some farmers to consider direct payments more favorably and to look more critically at surplus-diversion methods. This trend may have continued with the further decline in farm prices and incomes during 1955. Perhaps Michigan farmers are ready to give serious consideration to some alternative to the present methods in agricultural programs.

FARMERS' PLANS TO CHANGE LIVESTOCK NUMBERS AS RELATED TO AGRICULTURAL PRODUCTION CONTROLS

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MARKETING QUOTAS for wheat, put into effect in 1954, made acreage allotments more effective on farms with more than 15 acres of wheat. As a result of the reduced wheat acreage many Michigan farmers had to plan their farm organization in a new perspective.

The marketing quotas for wheat were effective in reducing wheat acreage because they provided that farmers with wheat acreage allotments of more than 15 acres be required to comply with allotments or pay a substantial cash penalty on wheat grown in excess of the allotment. The penalty for exceeding corn allotments only involved the loss of eligibility for price supports on corn.

Farmers faced with these new alternatives might be expected to view livestock production somewhat differently than before. In some cases the diverted acres may be devoted to hay and forage, making it possible to increase certain types of livestock. In other cases, farmers may have made reductions in both wheat and corn acreage; possibly leading to smaller feed supplies and reduced livestock numbers, or to shifts in the type of livestock.

A survey of 414 Michigan farmers, including 333 with some type of livestock, gives an indication of the changes which farmers were planning. This report deals only with plans to change livestock numbers.

FARMS SURVEYED

Slightly over 400 farmers in Kalamazoo, Gratiot, Isabella, Sanilac and Livingston Counties were interviewed during the summer of 1954. All of these farmers had wheat allotments of 15 acres or over. On some farms, special circumstances may have made compliance less difficult; others already had reduced wheat acreage; yet all these farmers re-

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ceived allotments which required a reduction from the average acreage of the previous 3 years. Failure to do so meant the payment of penalties.

Thus, the sample included primarily those farmers who had recently considered or were currently considering how to adjust their farm organization to the production control program.

Changes in livestock numbers or in the type of livestock produced is one of the important ways by which farmers can adjust to acreage allotments and marketing quotas. Since some changes may be due to factors other than controls, farmers were asked the reasons for changes in their livestock enterprises, so that the effect of control programs could be clarified. The adjustments planned are discussed below, followed by the reported reasons for the changes.

PLANS TO CHANGE LIVESTOCK NUMBERS

Of the 333 farmers interviewed who raised livestock, about 42 percent expected to increase livestock numbers. Just over half the farmers expected no change or did not answer. Only 8 percent expected to decrease livestock numbers. Of those farmers increasing livestock, about 20 percent expected to increase at least two types of

TABLE 1—Farmers' plans for changing livestock numbers

	Number
Plan to increase:	
Dairy and heifers	52
Beef cows and feeders	44
Sows and hogs	36
Other livestock	9
	141*
Plan to decrease:	
Dairy and heifers	18
Other livestock	9
	27†
Total farmers planning changes	168
No change expected	149
No answer	16
Total farms with livestock	333

*Of these farmers, 29 were planning increases in several types of livestock; 11 were planning a decrease in one and an increase in another.

†Six of these farmers were increasing another type of livestock; two were decreasing several types.

livestock; while less than 10 percent planned to decrease one type while increasing another. One-fifth of those farmers decreasing planned an offsetting increase in other types, and only two reported plans for a decrease in several types of livestock (see Table 1). These data indicate that control programs were encouraging an expansion of livestock production.

Dairy cows and heifers were the type of livestock for which the greatest percentage of farmers planned increases or decreases. The next greatest change involved beef cows and feeders. Since both types of livestock are important roughage-consuming animals, this suggests that larger hay and forage supplies were having an influence. It is significant that 36 farmers (about 10 percent) planned to increase sows and hogs (mostly the latter) indicating that the grain supply, on these farms at least, was not considered as a limiting factor.

CHANGES PLANNED IN LIVESTOCK NUMBERS AS RELATED TO PRESENT INTENSITY OF LIVESTOCK PRODUCTION

The changes planned were related to the number of acres per animal unit. (An animal unit is one cow or the equivalent number in feed consumption of other types of livestock.) While this is only a rough measure of the adequacy of the farm to provide feed for the livestock, it was thought that such a comparison might show where many of the differences occurred. The results of these comparisons are shown in Table 2.

Farmers who were already operating a relatively intensive livestock enterprise (6 acres or less per animal unit) were less likely to be plan-

TABLE 2—Relationships between intensity of livestock enterprise and plans to change livestock numbers

No. of acres in farm per animal unit	Percent of farms	
	No changes planned	Plans to change livestock numbers
10 acres and over	46	54
7 to 10 acres	36	64
Sub-total	43	57
2 to 6 acres	52	48
Total farms reporting	149	169

ning changes than farmers who were relatively more extensive. Moreover, the intensive livestock farmers who were planning changes were more likely to be planning decreases than those with extensive enterprises. Over 60 percent of the farmers planning to decrease livestock already had intensive livestock enterprises.

The major inference, however, is that regardless of present intensity, most of the farmers making changes were planning to increase livestock production. The relationships suggest that a few of the intensive farmers anticipated that the allotment program would reduce their feed supply. Others, and particularly farmers with less intensive livestock operations, appeared to have greater opportunities to expand livestock. Presumably, some of these increases were planned to utilize hay and forage to be grown on the diverted acres (see Table 6 page 516).

TABLE 3—Relationship between changes planned in livestock operations and age of operators

Changes planned	Age of Operator					
	Under 25	25 35	36 45	46 55	56 65	Over 65
	Percent					
No change.....	39	38	43	46	56	70
Increase livestock.....	53	59	50	42	30	26
Decrease livestock.....	8	3	7	12	14	4
	100	100	100	100	100	100
Farmers reporting.....	13	67	92	65	50	23

CHANGES PLANNED RELATIVE TO AGE OF OPERATOR

When changes are related to the age of the operator, another striking relationship is shown. Changes either up or down in livestock numbers are less likely to be part of the plans of the older operators, particularly those over 65; 70 percent of these reported that no changes were planned (See Table 3).

On the other hand, younger farmers were likely to be planning changes; in most cases, these changes were increases in livestock numbers. In fact, over 50 percent of the farmers under 45 years-old were planning livestock increases. Only in the case of farmers between

46 and 65 years of age did planned decreases include more than 8 percent of the farmers.

It is not possible to attribute these increases or decreases entirely to the control program. Some of the changes would occur as part of normal life cycles. It appears that farmers under 45 or 50 years of age were more likely to make adjustments in attempts to maintain or increase their size of business.

A group of specialized dairy farmers were selected for analysis. The differences were even more marked, as shown in Table 4. Nearly all the farmers planning decreases were 45 years or older. Over half of the farmers under 45 years-old were planning increases in livestock. About two-thirds of these were planning to increase the dairy enterprise; many of them planned to add other livestock as well.

TABLE 4—Relationships between planned changes in livestock operations by specialized dairy farmers and age of operators

Changes planned	Age of Operator					
	Under 25	25 35	36 45	46 55	56 65	Over 65
	Percent					
No change	43	46	41	43	48	88
Increase livestock	57	51	53	44	30	12
Decrease livestock	0	3	6	13	22	0
	100	100	100	100	100	100
Farmers reporting	7	35	51	23	23	8

These two relationships were further checked by comparing the ages of farmers with intensive and extensive operations as to their plans for increases, decreases or no changes in their livestock enterprise. No important differences were noted in this comparison.

COMPARISONS OF FARMERS ON THE BASIS OF SPECIALIZATION

The farms were divided into specializations on the following basis: A dairy farm had more than five animal units with 50 percent or more in dairy. Similar criteria were used for beef, hogs and others. A general farm was one on which no single category of livestock ac-

counted for 50 percent of the animal units. A "small" livestock farm had five animal units or less.

These farms were compared with respect to changes planned in livestock. There appeared to be no important differences between farmers specializing in one type of livestock, except that intensive dairy farmers were a little less likely to decrease than were farmers specializing in other types of livestock. The substantial capital investment in dairy facilities and the expectation that hay and forage would be available in larger amounts would account for this difference.

REASONS GIVEN FOR MAKING CHANGES

After the farmers had indicated the changes they planned, they were asked their reasons for these changes. Their answers have been summarized in Tables 5 and 6.

TABLE 5—Reasons given by farmers for planning increases in livestock production, by type of livestock

Reason given	Percent			
	Dairy	Beef	Hogs	Other
Utilize additional forage	12	29	7	25
Utilize additional corn or crops	9	11	17	0
Better labor management or use of less labor	12	13	2	12
Increase income	25	21	44	12
Have unused building	12	2	2	13
Need something to use labor	3	2	4	0
Allotment or government program	9	12	7	0
Other reasons	18	10	17	38
	100	100	100	100

TABLE 6—Reasons given by farmers for planning decreases in livestock production, by type of livestock

Reason given	Percent	
	Dairy	All others
Use less labor	45	28
Increase income	35	6
Allotment or government program	0	11
Other	20	55
	100	100

The most important single reason given for planning increases in livestock was that increased income was expected as a result of the change. This was true for both dairy and hog enterprises. It may be noted that emphasizing hogs rather than dairy probably was an error in judgment for the 1954-55 period, though possibly not for the longer period.

The second most important reason given for an increase was to utilize additional forage. This was the most important reason given for increasing the beef enterprise, and was also important for the dairy enterprise. A number of farmers indicated that the livestock enterprise was being expanded to utilize corn or other crops (possibly because they planted in excess of allotments and were not able to use the loan and purchase program).

Changes which would use less labor were given by a number of farmers as the reason for shifts in the type of livestock and was the most important reason among those planning a decrease. This was particularly true for decreases in the dairy enterprise. A few farmers reported expanding in order to better use the labor which was available on their farm.

In a few cases, farmers expanded one type of livestock while decreasing another. Thus, four farmers who were decreasing the dairy enterprise were at the same time planning an increase in the number of beef cows. Such a shift would reduce the labor requirements, continue to utilize some labor, and provide an outlet for forage.

Changes and adjustment continue to occur in a dynamic agriculture for a wide variety of reasons. Yet it is evident that allotments and marketing quotas are important influences upon farmers' decisions. Some farmers attributed planned changes directly to the programs.

Many others were planning increases in livestock to utilize larger feed supplies or available labor as acres were diverted to wheat. Still others were striving to provide income to replace that formerly supplied by the cash wheat crop. Finally, items not related to the control programs were most important in the decisions of about one-fourth of the farmers planning increases in livestock.

COMPARISONS OF PART-TIME AND FULL-TIME FARMERS

Even though the farmers interviewed were chosen to sample the commercial farmers, there was still a substantial number of farms with income from off-farm work. Of the 414 farmers interviewed, 86 received 50 percent or less of their income from farming operations.

Of the 333 livestock farmers, only 49 received 50 percent or less of their income from farming. Less than one-sixth of the livestock farms were part-time farmers; while nearly one-half of the farmers with no livestock (37 of 81) received half or more of their income from off-farm activities.

Among the livestock farmers, plans for changing were virtually the same. The slight differences between part-time and full-time farmers were not significant. There was a small indication that part-time farmers were more interested in beef and less interested in hogs than other farmers, but the differences were not great.

The interest in expansion by these part-time farmers is greater than might have been expected. Apparently, if these farmers have any livestock at all they are willing and able to expand as readily as other farmers. Thus, the effect of control programs is much the same. The major differences are that a relatively greater number of part-time farmers have no livestock at all.

OTHER COMPARISONS

Comparisons were made between owners, tenants, part-owners and those operating under other tenure arrangements. No differences were evident in regard to changes planned in the number of livestock. Part-owners, however, appeared to be more likely to expand the beef and hog enterprises than were either full owners or tenants.

As part of the analysis, farmers were asked whether they regularly, sometimes, or never attended county agent meetings. Cross comparisons of attendance at meetings with plans to change suggest that those attending meetings were more apt to be planning changes in their livestock program (see Table 7).

TABLE 7—Plans for changes in livestock by attendance at county agent meetings

Attendance	No change	Plan changes	No change	Plan changes
	Number		Percent	
Don't go	71	60	54	46
Sometimes go	28	36	44	56
Usually go	47	72	40	60

This relationship does not mean that attendance at meetings is necessarily responsible for the changes. Rather, it may suggest that farmers who are more alert, or farmers who are facing decisions with respect to their farming operations, are somewhat more likely to participate in meetings in the hope of obtaining new ideas or comparing their choices with the decisions or advice of other people.

SUMMARY AND CONCLUSIONS

At the time of the study, nearly half the livestock farmers were planning changes in their livestock numbers. In many cases, the acreage allotments for wheat and corn, and marketing quotas for wheat were important influences in these decisions. Over four-fifths of the changes planned were for an increase in the number of livestock. Thus, over 40 percent of the farmers receiving wheat quotas of 15 acres or more (and presumably reducing wheat acreage as a result) were expanding livestock.

In general, it may be said that many changes are being made in Michigan agriculture which tend to be lost in aggregate data. On farms with wheat acreage allotments, the younger farmers with extensive livestock enterprises and those attending county agent meetings are much more likely to be expanding livestock numbers in an effort to increase income and to utilize additional forage.

Some of the older farmers, those with already intensive livestock enterprises, and those who participate less in extension meetings also may be included among those expanding; but, in general, these farmers are more likely to remain the same or to reduce livestock. The latter differences are due to other factors which, at present, appear to be more important to this group of farmers than the impact of production controls.

Nevertheless, the most significant fact coming out of this study is the extent to which farmers were planning an expansion of livestock. While some time must elapse before the extra output reaches the market, it is clear that many Michigan farmers are adjusting to acreage controls by shifting to feed crops, pasture, and livestock production.

Thus, production control programs for one or a few commodities not only shift the pressure to supplies and prices of other crops, but to other livestock, especially to dairy and beef cattle after a period of time. Such shifts must be borne in mind in planning or revising extended farm programs.

GROWTH OF PLANTED BLACK WALNUT ON THE MICHIGAN STATE UNIVERSITY CAMPUS

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BLACK WALNUT (*Juglans nigra* L.) is a very valuable tree species, usually occuring in natural stands in southern Michigan as scattered individuals in mixture with other hardwoods. Planting of this species in the state has not been extensive, although a number of small plantations have been established. One of the oldest black walnut plantations in southern Michigan is located on the Michigan State University campus at East Lansing.

This plantation was established in 1910 on 0.9 of an acre in the northwest corner of the Baker Woodlot. It has gently rolling topography, with a heavy muck soil on the lower portions grading into Hillsdale sandy loam on the higher portions. The area was cleared of trees and plowed in 1909, and a tile drain was laid to remove surplus water from the lowest portion of the area which was inclined to be wet.

Northern white cedar (*Thuja occidentalis* L.) was planted in alternate rows with the black walnut to shade out weed growth and to provide side competition for the black walnut, thereby encouraging natural pruning. Northern white cedar is a shade-tolerant, slow-growing species, while black walnut is a shade-intolerant, more rapidly growing species.[1]

The rows were 4 feet apart, with the trees 4 feet apart in the rows. Computed on a per acre basis, this spacing resulted in 1,062 black walnut and an equal number of northern white cedar per acre. Year-old black walnut seedlings and 4-year-old northern white cedar transplants were used. The trees were cultivated the first year, and the weeds were cut with a scythe the following 2 years.

[1]Baker, F. S. (1921). Black walnut, its growth and management. U. S. Dept. Agr. Bul. 933. 43 pp.

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TABLE 1—Stand and stock table: black walnut plantation at 18 and 21 years of age, Michigan State University campus, 1928 and 1931

D.B.H. inches	Stand data, 1928*		Stand data, 1931*					
			Before thinning		Removed in thinning		After thinning	
	No. of trees per acre	Vol. per acre, cu. ft.	No. of trees per acre	Vol. per acre, cu. ft.	No. of trees per acre	Vol. per acre, cu. ft.	No. of trees per acre	Vol. per acre, cu. ft.
2	54.4	21.8	54.4	21.8	33.3	13.3	21.1	8.5
3	81.0	64.8	75.6	58.2	40.0	32.0	35.6	26.2
4	127.7	191.5	124.4	186.5	43.3	64.9	81.1	121.6
5	134.3	402.9	132.2	396.3	28.9	86.6	103.3	309.7
6	89.9	413.6	87.8	403.4	4.4	20.4	83.4	383.0
7	33.3	233.1	27.8	194.3	2.2	15.5	25.6	178.8
8	8.9	84.4	7.8	73.8	....	....	7.8	73.8
9	1.1	14.0	5.6	69.9	....	....	5.6	69.9
10	....	....	1.1	18.0	....	....	1.1	18.0
Totals	530.6	1,426.1	516.7	1,422.2	152.1	232.7	364.6	1,189.5

*Cubic-foot volumes include the entire tree stem and are based on Table 6 in Chittenden, A.K., and P. W. Robbins (1930). The farm woodlot in Michigan. Mich. Agr. Expt. Sta. Spec. Bul. 196. 28 pp.

After five growing seasons, there was strong competition by 1915 among the black walnut and the northern white cedar for light and growing space. Mortality in the walnut had been severe, resulting in only 576 living trees per acre. At that time, it was decided the cedar were no longer needed for their shading and side-crowding influence. Accordingly, most of the cedar were removed. The mortality among the walnut and the removal of the cedar left the remaining walnut trees with ample room for rapid growth.

Since 1915, the plantation has been inventoried several times and some thinnings have been made. Data taken in 1928 when the trees were 18 years-old, and again in 1931 when the first thinning was made, are summarized in Table 1.[2]

The thinning in 1931 was intended to relieve crowded conditions within the stand which had resulted in the loss of approximately 14 trees per acre and a decrease in volume during the previous 3-year period.

In the winter of 1933-1934, a second thinning was made (the number of trees and volumes are listed in Table 2).

[2]Robbins, P. W. (1928). Walnut interplanted with cedar grows rapidly. Mich. Agr. Expt. Sta. Quart. Bul. 10: 161-163.

TABLE 2—Trees and volume removed in thinning black walnut, 1933-1934

D.B.H. inches	No. of trees removed per acre	Volume removed per acre, cu. ft.*
2	3.3	1.3
3	11.1	8.9
4	26.6	39.9
5	44.4	133.2
6	24.4	112.2
7	13.3	93.1
8	7.8	74.1
9	8.9	112.1
10	1.1	17.8
Totals	140.9	592.6

*Cubic-foot volumes are based on Table 6 in Chittenden and Robbins (op. cit.), and include the entire tree stem.

Although data for the residual stand after the 1933-1934 thinning are not available, it is apparent that the thinning was heavy. More than one-third of the trees remaining after the 1931 thinning were cut, leaving approximately 220 trees per acre in the residual stand.

In 1936, a tally of the trees on a half-acre plot in the center of the plantation showed that the number of trees per acre had decreased to 211.1, with a volume of 1,191.7 cubic feet per acre.

Current data for the plantation were obtained in the fall of 1955.[3] Approximately half the trees in the stand are now above the 10-inch d.b.h. minimum sawlog size. Most trees average 35 feet of clear bole. The crowns are rather narrow and very short, with about 20 percent of the total tree height composed of live crown. These small live crowns are inadequate for maintaining optimum growth; therefore, a light thinning was made in the winter of 1955 to give the tree crowns more room to expand. Data for the stand before and after thinning are listed in Table 3.

The volume growth of the plantation is increasing, even though the number of trees has continued to decrease. There are still 12 northern white cedar remaining on the area, but they are no more than scraggly understory shrubs at the present time. Thirty-eight elm and black cherry, ranging in size from 1 to 8 inches d.b.h., had seeded into the area and were removed with the thinning.

High mortality and fairly slow growth have characterized the development of this plantation in the past. It now stands at approxi-

[3]Professor R. E. Dils, formerly of the forestry department staff, assisted in the early stages of this inventory.

TABLE 3—Stand and stock table for 45-year-old black walnut plantation: Baker Woodlot, Michigan State University campus, 1955

D.B.H. inches	Before thinning				Removed in thinning			After thinning		
	No. of trees per acre	Average total ht. (ft.)	Vol. per acre		No. of trees per acre	Vol. per acre		No. of trees per acre	Vol. per acre	
			Cu. ft.*	Bd. ft.†		Cu. ft.*	Bd. ft.†		Cu. ft.*	Bd. ft.†
3.....	2.2	20.0	...	...	1.1	...	...	1.1	....	...
4.....	2.2	30.0	...	...	1.1	...	...	1.1	...	...
5.....	3.3	40.0	6.0	...	1.1	2.0	...	2.2	4.0	...
6.....	4.4	47.5	14.9	...	1.1	3.7	...	3.3	11.2	...
7.....	8.8	53.3	49.3	...	4.4	24.6	...	4.4	24.7	...
8.....	17.8	60.8	151.3	...	4.4	37.4	...	13.4	113.9	...
9.....	22.2	65.7	263.7	...	5.6	66.5	...	16.6	197.2	...
10.....	30.0	64.2	469.5	630	1.1	17.2	23	28.9	452.3	607
11.....	17.8	68.1	352.4	445	2.2	43.6	55	15.6	308.8	390
12.....	15.6	72.7	381.1	889	...	...	...	15.6	381.1	889
13.....	5.5	68.0	162.3	374	...	...	...	5.5	162.3	374
14.....	1.1	73.3	38.5	154	...	...	...	1.1	38.5	154
15.....	3.3	72.5	133.5	528	...	...	...	3.3	133.5	528
16.....	1.1	60.0	50.8	198	...	...	...	1.1	50.8	198
Totals..	135.3	.....	2,073.3	3,218	22.1	195.0	78	113.2	1,878.3	3,140

*Cubic-foot volumes are adjusted to stand characteristics and converted to cubic feet; they are based on Table 5 in Gevorkiantz, S. R., and L. P. Olsen (1955). Composite volume tables for timber and their application in the Lake States. U. S. Dept. Agr. Tech. Bul. 1104. 51 pp.

†Board-foot volumes are based on Table 2, ibid.

mately the halfway mark in terms of its final rotation age. The majority of the remaining 113 trees per acre should be held to make final crop trees. With adequate room for all trees to grow, the sawlog volume of this stand (and thereby its value) should increase rapidly in the future.

MOLYBDENUM DEFICIENCY AND NITRATE TOXICITY ON CONCORD GRAPES

By ERNEST L. BERGMAN and A. L. KENWORTHY
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EXPERIMENTAL PROCEDURE

IN EARLY JULY OF 1955, rooted cuttings of Concord grapes (*Vitis labrusca*) were lifted from the nursery row and planted in quartz sand at the university farm in East Lansing. The cuttings were grown out-of-doors with nutrient solutions until September 9 when they were moved into the greenhouse. Hoagland solution (Hoagland and Arnon, 1950) was used as a standard complete solution and as a basis for making solutions having low and high levels of 10 nutrient elements. No

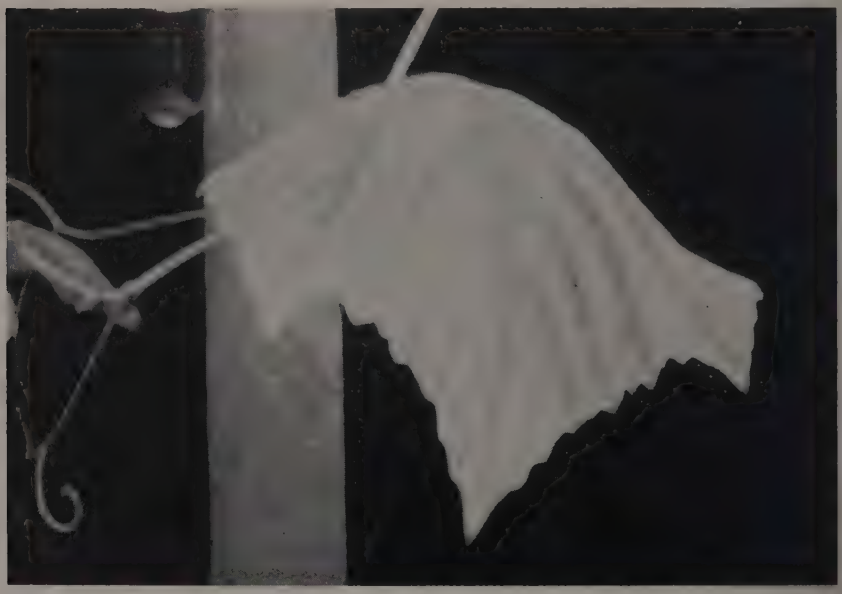

Fig. 1. Terminal leaf of Concord grape plant showing chlorosis resulting from molybdenum deficiency.

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molybdenum was added to the solutions because the chemicals (CP grade) were used without purification.

Many of the plants showed chlorotic leaves on the terminal portions of the shoots by September 1. Ferrous sulfate and chelated iron (ferric ethylenediamine tetraacetate) were tried but did not correct the chlorotic condition. The plants, irrespective of treatment, were showing chlorotic leaves on the shoot tips (Fig. 1) and necrotic conditions on the basal leaves (Fig. 2) by October 25.

The symptoms suggested a deficiency in the tip leaves and a toxicity in the basal leaves. Plants receiving treatments of minus calcium, high nitrogen, and urea did not show these symptoms. The solutions for these treatments contained some ammonia and/or urea. In other solutions, only nitrates were used as a source of nitrogen.

Reports by Ichioka and Arnon (1955) and Stout and Meagher (1948) suggested that the observed conditions may have been an occurrence

Fig. 2. Basal leaf of Concord grape plant showing marginal necrosis resulting from nitrate toxicity induced by molybdenum deficiency. (Necrosis developed concentrically from leaf margin.)

of molybdenum deficiency in the terminal leaves and nitrate toxicity in the basal leaves. Ichioka and Arnon (1955) reported that molybdenum was essential for the assimilation of nitrates but not for the assimilation of ammonia and urea. Stout and Meagher (1948) found that molybdenum deficiency resulted in high nitrate accumulation in tomato leaves.

Qualitative nitrate tests, using diphenylamine reagent (Scott, 1939) indicated that nitrates were very high in the leaf blades and still higher in the necrotic areas. Under normal conditions, grape leaves contain but slight amounts of nitrates.

On November 9, 0.01 p.p.m. molybdic acid was added to the nutrient solution for one replicate of the treatments. The development of necrotic leaves was immediately arrested. Chlorosis of the terminal leaves was reduced and new leaves developed. The untreated plants ceased growing and necrosis continued to develop.

Analyses (Benne and Jerrim, 1955; Dick and Bingley, 1947) showed that petioles from nontreated plants contained 0.2 p.p.m. of molyb-

Fig. 3. Terminal portion of grape plant showing method of supplying molybdenum solution through leaf petiole. (Terminal leaves show chlorosis, lower leaves show necrosis.)

denum; the petioles from plants receiving molybdic acid in the solution contained 3.4 p.p.m. molybdenum. Diphenylamine tests after 2 weeks of treatment showed that the presence of nitrates in the leaf blade was reduced markedly.

A plant from the minus manganese treatment was used for injection studies. The terminal leaves were chlorotic but did not show typical manganese deficiency symptoms. Molybdic acid solution (0.01 p.p.m.) was drawn into the plant by inserting a petiole into a vial containing the solution (Fig. 3).

The petiole remained in the solution for 15 days. Three days after inserting the petiole into the molybdic acid solution, the veins of the terminal leaves began to show green color. Two weeks after the molybdenum solution was supplied, the terminal leaves showed typical manganese deficiency patterns. Analyses of petioles showed that 13.5 p.p.m. of molybdenum was present above and 0.5 p.p.m. was present below the petiole supplied with molybdic acid solution.

SUMMARY

These data and observations indicated that the plants were affected with molybdenum deficiency which expressed itself as symptoms of chlorosis in terminal leaves and as nitrate toxicity in the lower leaves. The use of ammonia and urea prevented the expression of molybdenum deficiency. Although standard values for molybdenum supply and content for grapes has not been established, these data indicate that expected contamination from nonpurified chemicals was not adequate to prevent molybdenum deficiency.

LITERATURE CITED

Benne, E. J., and D. M. Jerrim (1956). Report on molybdenum in plants. Jour. Assoc. Official Ag. Chemists. In Press.

Dick, A. T., and J. B. Bingley (1947). The determination of molybdenum in plant and in animal tissue. Australian Jour. Exp. Bio. Med. Sci. 25: 193-202.

Hoagland, D. C., and D. I. Arnon (1950). The water culture method for growing plants without soil. Calif. Agr. Exp. Sta. Circ. 347. 32 pp.

Ichioka, P. S., and D. I. Arnon (1955). Molybdenum in relation to nitrogen metabolism. II. Assimilation of ammonia and urea without molybdenum by scenedesmus. Physiol. Plant. 8:552-560.

Scott, W. W. (1939). Diphenylamine indicator solution. A chapter, p. 1205, in Scott, W. W. *Standard Methods of Chemical Analysis* (1939). 5th ed., Vol. 1. D. van Nostrand Co., New York.

Stout, P. R. and W. R. Meagher (1948). Studies of the molybdenum nutrition of plants with radioactive molybdenum. Science 108: 471-473.

THE LOSS OF NUTRIENTS BY LEACHING OF THE FOLIAGE[1]

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SINCE ABOUT 1900, isolated reports have appeared suggesting that nutrients can be lost from leaves during rainfall. Chemists who analyzed plant tissues suspected the phenomenon even prior to 1890. However, except for a few preliminary studies, little or no attention, mention, or recognition of nutrient losses from the leaching of foliage and other aerial plant parts by rain has been given.

While suspected by some, the possible significance of these losses in agricultural production were largely ignored until spectrographic and chromatographic methods of analysis and the availability of radioisotopes enabled the research worker to make precise and quantitative measurements.

As early as 1908, LaClerc and Breazeale reviewed the results of others and reported some research of their own. They soaked or sprayed plants (barley, wheat, apple, and rice) with distilled water and made chemical analyses of the leaves and leachates. Losses up to 75 percent of some of the elements occurred, with a five-to-tenfold increase in mature wheat plants as compared to flowering plants.

Mann and Wallace (1925) reported 30, 50 to 60, and 80 to 90 per cent losses of dry matter, ash, and potash, respectively, when apple leaves were intermittently soaked with distilled water and dried.

Lees (1926) has suggested that the previous season's rainfall apparently decreases apple yields, presumably by affecting the number of fruit buds. Tamm (1951) and Will (1955) have reported considerable losses of ash, organic matter, calcium, potash, and sodium from the leaves of coniferous and hardwood forest trees following rainfall. Losses of phosphorus and nitrogen were much less.

Similarly, Dalbro (1955) has shown that organic matter, potash, sodium, and calcium are lost in the rain which leaches the foliage

[1]This work was supported by the Atomic Energy Commission Biological and Medical Division, Contract No. AT (11-1)-159.

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of mature apple trees. He gives the total quantity lost as about 800 to 900 pounds per acre, of which 20 to 30 pounds were potash and 10 pounds each were calcium and sodium. The remaining fraction, and by far the largest, was organic.

Lausberg (1935) found that when intact leaves were leached under natural rainfall or intermittently soaked and dried, they lost considerable potassium and chloride, and lesser amounts of magnesium, calcium, sulfate, and phosphate. She found losses from the upper surface of leaves to be 20 to 67 percent greater than from the lower surface. Light rains appeared to remove more nutrients per volume than did heavy rains. Losses were greater from mature leaves, and varied greatly with the plant species tested. Nutrient leaching by rainfall was much less from species having heavily cutinized leaves.

In the only study other than our own in which radioactive isotopes have been utilized, Mes (1954) reported losses up to 11 percent of previously root-absorbed radioactive phosphorus (p^{32}) from tomatoes, beans, potatoes and corn under conditions of natural climate and rainfall over a period of 30 days. Losses up to 5 percent of the phosphate which had been taken up by the roots occurred when the foliage was soaked or sprayed with water (both natural and artificial rain). These losses were attributed both to a washoff of surface-excreted salts and to a dissolving or washing out of those salts present in the intercellular spaces of the leaves.

EXPERIMENTAL PROCEDURE

Loss of nutrients by water leaching of foliage was studied by use of radioisotopes and by comparative chemical analysis of plants before and after water leaching (6). Losses were higher with isotopic tracers, suggesting that the more recently absorbed nutrients were the first to be lost from the plant. No phosphate (p^{32}) was removed from the foliage of bean, poinsettia, or sweet potato plants during 48 hours under a mist of distilled water. However, 2.2 percent of the previously root-absorbed potash (K^{42}) was removed from bean plants in a 4-hour period.

In other experiments with beans, 5 to 71 percent of the potash (K^{42}) and 5 to 14 percent of the rubidium (Rb^{86}) were leached from the foliage in 4 hours. The percent lost varied with the salt content of the nutrient solution and the light supplied. Chemical analysis of bean foliage before and after leaching showed approximately a 10 percent reduction in calcium, potash, nitrogen, magnesium, and phosphate.

TABLE 1—Loss of nutrients from leaves of intact plants and from cuttings under artificial rain, as determined by radioactive tracers

Plant	Tracer	Hours leached	% Lost*
Data of Mes (1954)			
Tomato	P^{32}	0.5	5.0
Potato	P^{32}	0.5	2.7
Corn	P^{32}	0.5	2.7
Bean	P^{32}	0.5	2.2
Data of Long et al. (1955)			
Rose†	P^{32}	48	12.8
Bean†	P^{32}	48	1.5
Bean	P^{32}	48	0.0‡
Sweet potato	P^{32}	12	0.0
Bean	K^{42}	4	2.2
Bean	Rb^{86}‡	4	5-14§
Bean	K^{42}	4	5-71§

*0.0 values not necessarily zero, but are not significant above background count rate.
†Intermediate and terminal cuttings which absorbed P^{32} through the bases of the cut stems.
‡Data from three different experiments.
§Ranges due to interaction of nutrient level and light.

Losses appeared to be directly correlated with the length of leaching time and with the amount of water used. These results are summarized in Tables 1 and 2, along with those of the other workers noted above.

TABLE 2—Loss of nutrients from leaves by natural or artificial rain or by soaking, determined by chemical analysis of leached and nonleached leaves and leachates

Source of data	Plant	Unit of measure	Nutrient lost*					
			Ca	K	N	P	Ash	O.M.
Curtis (1944)	Ryegrass	p.p.m.	....	40.0	5.0	4.0	....	....
Dalbro (1955)	Apple	Kg/ha	10.0	25.0	†	†	....	350
LaClerc (1908)	Cereals	%	0.0	4.0	1.0	0.0	....	....
Long (1955)	Bean	%	11.0	17.0	11.0	9.0	....	‡
Mann (1925)	Apple	%	....	85.0	....	....	50	30
Tamm (1951)	Pine	mg/l	5.0	6.0	0.0	0.2	48–64	14–94
Will (1955)	Pine	mg/m^2	3.4	20.0	....	5.0	....	....

*Quantities varied since experimental conditions vary greatly.
†Determined quantitatively but amounts varied greatly.
‡Qualitative determination only.

When the organic fraction of the leaf leachate samples was concentrated by vacuum or chromatographic methods, a large quantity of dark brown gum and a very small amount of proteinaceous material was found. When hydrolyzed with acid, the gummy substance yielded a sugar, and the proteinaceous fraction yielded several amino acids. The acid hydrolyzed leachate gave a positive test for reducing sugars with Fehling's solution, while the original leachate did not. As a phenylhydrazine derivative (osazone), the sugar was identified as galactose. Hydrolyzed leachates from tomato and cherry leaves also contained galactose.

These results suggest that the gum in the original leachate was a "galactan". The small quantities of leached polypeptid were too small to be identified. However, four or five amino acids were present upon hydrolysis.

With cherry cuttings under mist propagation (Sweet and Carlson, 1955), it was observed that cells in the spongy mesophyll of the leaf sometimes separate after prolonged leaching (25 to 50 days). Cracks appeared in the leaf epidermis and cuticle. Globules and granules, typically present in leaf cells, disappeared. Fruit buds were formed on some of the cuttings, and the growth of shoot buds was much reduced. Further, symptoms sometimes appeared which were characteristic of nutrient deficiency disorders.

SUMMARY AND CONCLUSIONS

From these and other published results, it would appear that leaching from leaves by rainwater does occur. The losses are considerable, and may warrant serious attention in crop production and fertilizer usage. The nutrient content of the plant, the plant species, sunlight, maturity, and the amount and duration of rainfall are among factors which determine loss. The full significance and practical importance of these findings are still to be determined.

LITERATURE CITED

Curtis, L. C. (1944). The exudation of gultamine from lawn grass. Pl. Physiol. 19: 1-5.

Dalbro, Sven (1955). Leaching of nutrients from apple foliage. Proc. XIV International Hort. Cong. (Paris). In Press.

LaClerc, J. A., and J. F. Breazeale (1908). Loss of plant food by action of rain or dew. Yearbook of Agriculture, 1908. pp. 389-402. U. S. Dept. Agr., Wash.

Lausberg, T. (1935). Quatitative Untersuchungen uber die Kutikulare Exkretion des Laubblattes. Jahrbuch. Wiss. Botan. 81: 769-806.

Lees, A. H. (1926). Factors governing fruit bud formation. Long Ashton Expt. Sta. Rpt., Univ. of Bristol. pp. 42-59.

Long, W. G.; D. V. Sweet and H. B. Tukey (1955). The loss of nutrients from plant foliage by leaching as indicated by radioisotopes. Science. In Press.

Mann, C. E. T., and T. Wallace (1925). The effects of leaching with cold water on the foliage of apple. Long Ashton Expt. Sta. Rpt., Univ. of Bristol. pp. 17-24.

Mes, M. G. (1954). Excretion (recretion) of phosphorus and other mineral elements under the influence of rain. S. African Jour. Sci. 50:167-172.

Sweet, D. V., and R. F. Carlson (1955). Rooting of cuttings in air-cooled mist chambers. Mich. State Agr. Expt. Sta. Quart. Bul. 38: 258-267.

Tamm, Carl Olaf (1951). Removal of plant nutrients from tree crowns by rain. Physiologia Plantarium 4:184-188.

Will, G. M. (1955). Removal of mineral nutrients from tree crowns by rain. Nature 176:1180.

ASSOCIATION OF FARM BUSINESS MEASURES WITH FARM INCOMES[1]

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THE PURPOSE OF THIS STUDY was to determine how gross farm and labor income are associated with nine farm business measures. The nine measures selected for study were: (1) Tillable acres, (2) number of cows, (3) productive day's work (P.D.W.), (4) productive day's work per man, (5) crop yield index, (6) livestock income per tillable acre, (7) tillable acres per animal unit, (8) dairy sales per cow and (9) income per $100 expense. These are computed and published in the Farm Business Analysis reports of the Cooperative Extension Service, Michigan State University.

The **first three** of the nine measures selected are commonly regarded as **measures of input**. Although productive day's work is not commonly used as a measure of output, it is an index of output with labor requirements used as weights in combining products. **Five of the last six** are measures of efficiency as they are ratios between inputs and outputs; while the other, tillable acres per animal unit, is a ratio between two inputs.

The study is based on data for 1952 from 124 farms in south-central Michigan.[3] Gross farm income and labor income were treated as dependent variables and the nine farm business analysis measures as independent variables. Means and standard deviations were computed for gross farm income and labor income. Following this, 18 simple linear regressions were fitted; nine between gross farm income and each of the nine independent variables, and nine between labor income and each of the independent variables. For each regression, the coefficient of determination, regression coefficient, standard error of

[1]Prepared as a result of a special problem in Agricultural Economics 405 under the supervision of Glenn Johnson who shares responsibility for the data and arguments presented. This article is, in part, a contribution under Project 442, Michigan Agricultural Experiment Station, which supplied I.B.M. services and the supervision of the advisor in converting the class report into publishable form.
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[3]Elwood, E. M.; J. M. Nielson, W. H. Vincent and J. C. Doneth (1953). Farm busines analysis —Area 5. Mich. State Univ. Ag. Econ. Bul. 514. 17 pp.

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estimate and the standard error of the regression coefficient were computed.

The mean labor income was $3,590, plus or minus a standard deviation of $3,698; and the mean gross farm income was $14,410, plus or minus a standard deviation of $8,209.[4]

MEASURES OF INPUTS

The three business measures commonly regarded as measures of input are tillable acres, number of cows and P.D.W. For purposes of estimating gross income, tillable acres and P.D.W. proved moderately reliable. Only P.D.W. proved reliable in estimating labor income.

The standard error for estimating gross income from regression lines was $3,354 for P.D.W. and $5,385 for tillable acres, contrasted to standard deviations ranging from $6,550 to $8,209 for average gross income. The standard deviation depends on which variable is under consideration since all variables did not occur on all the farms studied. The usefulness of tillable acres and P.D.W. in estimating gross income is further indicated by the coefficients of determination which indicate that variations in P.D.W. were associated with 84 percent of the variance in gross income, while variations in tillable acres were associated with 58 percent.

None of the other measures had standard errors of estimates as low or coefficients of determination as high as those for P.D.W. and tillable acres. P.D.W. has a standard error of estimate of $3,237 for estimating labor income, contrasted to a standard deviation of $3,697 for average labor income. The coefficient of determination indicates that changes in P.D.W. are associated with only 25 percent of the variation in labor income.

For purposes of **estimating changes in gross income** associated with changes in themselves, the three input variables were quite reliable. The regression coefficients for tillable acres, number of cows and P.D.W. range from 7 to 25 times as large as their standard errors of estimates. The regression coefficients indicate the change in gross income associated with unit changes in the inputs.

However, since changes in other variable inputs were not controlled or their influences measured, these changes in gross income are not easily compared with the unit cost of these inputs to determine the profit of adding or subtracting these inputs to a farm business. For this

[4]The means and standard variations for gross farm income and labor income were different when dairy sales per cow and tillable acres per animal unit were used as independent variables because some farms in the sample had neither dairy cow sales nor animal units. (See Tables 1 and 2).

latter purpose, estimates of the change in gross income associated with each input (other inputs remaining unchanged) are needed.

Thus, while the changes in gross income associated with changes in the three inputs and related factors of production can be reliably estimated, such estimates are of little significance in determining how much of each input to use, or in what proportion to combine it with other inputs, for maximum profits.

For purposes of **estimating** either the level of or changes in **labor income**, the three farm business measures dealing with inputs are poor, with the exception of P.D.W. which has some value.

EFFICIENCY MEASURES

Five of the nine farm business measures related in this study to gross farm income and labor income are commonly regarded as measures of efficiency. They are: Crop yield index; livestock income per tillable acre; dairy sales per cow; income per $100 of expenses; and productive day's work per man. Thus, these five variables should be expected to be closely related to labor income.

Despite this, variations in only one of the five measures were associated with more than 74 percent, and in only two cases with as much as 17 percent, of the variance in labor income. Variations in income per $100 of expense were associated with variations in labor income at the 74 percent level. Labor income estimates based on this variable were within $1,900 in 68 percent of the cases; its closest competitor was unable to do better than $3,385 in 68 percent of the cases. As the standard deviation of average labor income was around $3,700, use of regressions based on these efficiency measures adds very little to the accuracy with which labor income can be estimated.

Because changing these efficiency measures is often advocated as a means of increasing labor incomes, the efficiency with which **changes** in labor income can be predicted from changes in these measures was investigated. Estimating changes in labor income from changes in income per $100 of expense proved effective, the regression coefficient being $93.65 with a standard error of $5.02. All regression coefficients for the other efficiency measures had low standard errors.

Tillable acres per animal unit had a standard error over three times as large as its regression coefficient. As previously noted, this variable is not really an efficiency measure; thus, its high standard error is not surprising.

The high degrees of reliability for the efficiency measures in predicting changes in, but not the level of labor income, tends to be a result of accounting procedures; i.e., the association is not a casual one which can be exploited for maximum profits. Instead, the association is an accounting relationship, with both labor income and the "other" efficiency measures moving together as consequences of actions not measured by either.

Thus, neither the regression relationship nor the variables provide a basis for matching the cost of securing changes in labor income against the change in labor income as a basis for profit-maximizing decisions.

For purposes of **estimating gross farm income,** variations in none of the five efficiency factors were associated with more than 32 percent of the variance in gross income, and in only two cases with over 15 percent. The standard errors of estimates range from $5,456 for estimates of gross income based on dairy sales per cow to $7,808 when based on the crop yield index.[5] Within this range, all the standard errors of estimates (except the one for dairy sales) equal or exceed $7,553.

The standard deviations of average gross income ranged from $6,550 to $8,209, depending on which variable is under consideration as all variables did not occur on all farms studied. Significantly, the $6,550 standard deviation was for gross income on farms reporting dairy sales per cow and for which the $5,456 standard error of estimate occurred.

For purposes of estimating changes in gross income associated with changes in themselves, however, four of the five efficiency factors had standard errors of less than one-third their regression coefficients. While these measures are relatively accurate for making this type of estimate, it should be pointed out that accurate estimates of changes in gross income are most worthwhile when costs of securing such changes can be matched against the increase in gross income. Such comparisons cannot be made from these computations because other things change, and the independent variables are ratios, not inputs or costs.

[5]See footnote 4.

TABLE 1—Association of farm business measures with farm income

Independent variables	Dependent variables							
	Percent of variance in income association with independent variable		Prediction of the variability of income 68 percent of the time		Changes in income due to a unit increase in the independent variables		Accuracy of income associated with independent variables 68 percent of the time	
	Gross farm income	Labor income	Gross farm income	Labor income	Gross farm income	Labor income	Gross farm income	Labor income
			plus/ minus	plus/ minus			plus/ minus	plus/ minus
X_1 Tillable acres	57.6	7.0	$5385	$3595	$69	$11	$5	$4
X_2 Number of cows	29.7	18.7	6939	3361	435	155	61	29
X_3 Productive day's work	83.6	24.6	3354	3237	25	6	1	1
X_4 Productive day's work per man(productive day's work)	16.7	16.4	7553	3408	37	17	8	3
X_5 Crop yield index	10.9	8.4	7808	3568	137	54	35	16
X_6 Livestock income per tillable acre (dollars)	15.0	17.5	7630	3385	106	52	23	10
X_7 Tillable acres per animal unit (tillable acres)	.8	.1	8123	3740	—95	13	94	43
X_8 Dairy sales per cow (dollars)	31.8	14.9	5456	3408	33	13	5	3
X_9 Income per $100 expense (dollars)	15.7	74.0	7598	1900	96	94	20	5

TABLE 2—Means and standard deviations

Income measure	Independent variables		
	X_1 X_2 X_3 X_4 X_5 X_6 X_9	X_7	X_8
Mean gross income	$14,410	$14,450	$14,500
Mean labor income	3,590	3,600	3,760
Standard deviation for mean gross farm income	8,209	8,029	6,550
Standard deviation for mean labor income	3,698	3,712	3,661

GROWTH OF WHITE PINE IN SOME PURE AND MIXED PLANTINGS IN MICHIGAN

By VICTOR J. RUDOLPH, WALTER LEMMIEN and MAURICE W. DAY[1]

WHITE PINE (*Pinus strobus* L.) was the most important timber species in Michigan's original forests. Based largely on its original importance in the species composition of the state's forests, white pine has been commonly used in the establishment of both pure and mixed forest plantations.

Studies of the growth and development of white pine in several mixed plantings which are now of pulpwood size and larger have been made by a number of investigators. These studies provide an indication of the success of such plantings, and serve as a partial basis for species selection for future plantings.

Growth studies of white pine in mixture with red pine (*Pinus resinosa* Ait.) in plantations ranging from 20 to 41 years of age have been made by Skog (1951) in Michigan's upper peninsula, Gaiser and Merz (1953) in Ohio and Indiana, Hicock (1942) in Connecticut, Stevenson and Bartoo (1940) in Pennsylvania, and Guise (1945) in New York. The results of these studies have been summarized by Rudolph and Lemmien (1955) in a report on the growth of a mixed planting in the W. K. Kellogg Forest near Augusta, Michigan.

Except for Gaiser and Merz, all investigators reached essentially the same conclusions. They found that the survival of red pine was two to three times greater than that of the white pine, and that the red pine outgrew the white pine in diameter, height and volume. Some dominant white pine trees were found to be taller than the dominant red pine, but such trees formed a small component of the total stand.

On the other hand, Gaiser and Merz concluded that white pine outgrew red pine in diameter, height and volume in Ohio and Indiana. Their results, however, were based on measurements on each plot of

[1]Department of Forestry; Kellogg Forest; and Dunbar Forest Experiment Station, respectively.

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five dominant and five co-dominant trees only. Consideration of all trees of each species on the plots might have changed their conclusions.

The increasing problems of disease and insect infestation of the white pine were noted in the previous studies. Repeated attacks by the white pine weevil, *Pissodes strobi* (Peck), have contributed to the frequent overtopping of the white pine by the red pine. A condition described as white pine needle blight or "chlorotic dwarf" was cited by Rudolph and Lemmien (1955) as retarding the growth of some of the white pine in the Kellogg Forest. Trees affected eventually die, either from the disease or from suppression by adjoining overtopping trees.

Other investigators noted the occurrence of white pine blister rust, *Cronartium ribicola* (Fischer), in some areas, but its damaging effects in these fairly young plantations apparently have not been as serious as weevil attacks.

PLANTATIONS IN CHIPPEWA COUNTY

Adjoining the mixed red and white pine portion of a plantation in Chippewa County described by Skog (1951) are two smaller planted areas of approximately one-fourth acre each. One area consists of pure white pine; the other area is an irregular mixture of white pine, red pine, and jack pine. These areas are small, but they are distinct from the adjoining planting and are growing on essentially the same quality of site. Thus, differences in survival and growth provide valid indications of the suitability of these species for such plantings on similar areas.

These plantings were established in 1925 on abandoned farm land. The spacing was 6 by 7 feet. The topography is level, and the soil is Bohemian very fine sandy loam. Data for the pure white pine portion of these plantings are listed in Table 1.

The stand has an average d.b.h. of 6.6 inches, and an average total height of 32.3 feet. With a survival of 90 percent at 30 years of age, the present stand is dense. However, it is not of desirable quality. Most of the trees are very crooked and badly deformed from repeated attacks by the white pine weevil. Approximately 22 percent of the trees are in the intermediate or suppressed crown classes. Some infection by white pine blister rust is also present.

In the irregular mixture of white pine, red pine and jack pine, about 80 percent of the trees originally planted were jack pine. The

TABLE 1—Stand and stock table, 30-year-old white pine plantation: Chippewa County, Michigan, 1955

D.B.H. (inches)	No. of trees per acre	Vol. per acre (cu. ft.*)
2	12.5	....
3	12.5	....
4	100.0	....
5	37.5	36.7
6	237.5	598.5
7	212.5	837.3
8	150.0	855.0
9	25.0	187.0
10	12.5	122.0
Totals	800.0	2,636.5

*Volumes are based on Table 5 in Gevorkiantz and Olsen (1955), adjusted to stand characteristics and converted to cubic feet.

remainder was composed about equally of white pine and red pine. Because of the very erratic mixing of the three species, it was not considered possible to arrive at valid per-acre values for this portion of the plantation. However, all living white pine and red pine were measured, along with a representative sample of jack pine.

The jack pine has good form; it is straight and tall, and all trees are either dominants or co-dominants. Many of the white pine and red pine have died, and the remaining trees are spindly and of poor form. With the exception of a few co-dominant red pine, all others are badly overtopped and suppressed. At 30 years of age, average diameter and height data for the three species in this mixture are as follows:

	Jack pine	White pine	Red pine
Average d.b.h. (inches)	7.0	2.8	4.1
Average total height (feet)	48.0	21.3	30.1

Data for the mixed red pine-white pine portion of this plantation provide a marked contrast in development. Current measurements for the same area studied by Skog in 1951 are summarized as follows:

	No. of trees per acre	Av. d.b.h. (inches)	Av. total height (ft.)	Av. vol. per acre (cu. ft.)
White pine.....	170	4.4	33.4	136
Red pine.....	485	8.1	44.2	3,643
Total.....	655	...	....	3,779

Obviously, the white pine component of the stand is losing ground rapidly; while the growth of the red pine indicates that it is taking advantage of the resulting wider spacing.

In the Dunbar Forest, located in the eastern portion of Chippewa County, pure white pine was planted in 1929 with a spacing of 6 by 6 feet. The area was abandoned farm land. It has level topography, and the soil is Brimley very fine sandy loam. Data for this plantation of 10.8 acres are shown in Table 2.

Survival in this plantation has been good, but the trees are of very poor quality because of many crooked and divided stems, heavy branching, and wide crowns. These characteristics are the result of repeated attacks by the white pine weevil. Such attacks are continuing, and there appears little possibility of improvement in tree quality with age.

The trees have an average d.b.h. of 5.3 inches, and the dominant stand averages 29 feet in height. Earlier observations in this planta-

TABLE 2—Stand and stock table, 26-year-old white pine plantation: Dunbar Forest, Chippewa County, Michigan, 1955

D.B.H. (inches)	No. of trees per acre	Vol. per acre (cu. ft.*)
2.....	12	...
3.....	76	...
4.....	208	...
5.....	216	216
6.....	204	408
7.....	100	400
8.....	24	144
9.....	4	36
Total.....	844	1,204

*Volumes are based on Table 5 in Gevorkiantz and Olsen (1955), adjusted to stand characteristics and converted to cubic feet.

tion revealed uniform diameter growth until an age of 19 years; much slower diameter growth has followed since. The effects of weevil damage in retarding height growth, and the continued growth of the crowns in width, resulted in an acceleration of the normal process of crown closure. The wide, comparatively flat crowns press against each other, and the lower branches have died from shading.

Thus, only a relatively shallow top layer of the crown canopy is now alive. The live crown surface of this flat, shallow layer is small, and cannot support a normal or desirable rate of growth. Thus, much slower growth has taken place since crown closure occurred.

This plantation is heavily infested with white pine blister rust. By 1952, 56 trees per acre had died from this cause. An examination made in 1953 revealed that 116 trees per acre had trunk cankers. An additional 32 trees per acre had cankers on live branches. Removal of the branch cankers by pruning would save those trees for the time being, but those with stem cankers will probably die within a few years. Thus, a loss of 172 trees per acre appears certain.

This in itself would not ruin the plantation, even though some of the best potential crop trees as well as the less desirable individuals are affected. Furthermore, losses will continue, although it is impossible to forecast the rate of infection in the future. If approximately 24 percent of the stand is lost in the first 24 years of its life, it appears likely that there will be little left of the stand at 75 years of age.

As a contrast, an adjoining red pine plantation established with the same initial spacing 2 years earlier on a similar site has remained relatively free of insect and disease injury. There are 736 trees per acre, with an average d.b.h. of 6.8 inches, and an average height of dominants of 40 feet. The volume is 2,972 cubic feet per acre, which is approximately two and one-half times that of the white pine.

PLANTATIONS IN KALAMAZOO COUNTY

An alternate-tree mixed planting of white pine and jack pine was made on 1 acre in 1929 in the W. K. Kellogg Bird Sanctuary near Gull Lake. The soil is classified as Bellefontaine sandy loam. The area slopes gently to the north, and has good drainage. The initial spacing was 6 by 7 feet. Data for this plantation are listed in Table 3.

Developments to date in this mixed plantation parallel those in mixtures of white pine and red pine. At 26 years of age, there are twice as many jack pine as white pine per acre. The volume per acre of the jack pine is approximately three times that of the white pine.

TABLE 3—Stand and stock table for 26-year-old mixed white pine—jack pine plantation: W. K. Kellogg Bird Sanctuary, Kalamazoo County, Michigan, 1955

D.B.H. (inches)	No. of trees per acre		Merch. volume per acre*		
	White pine	Jack pine	White pine (cu. ft.)	Jack pine (cu. ft.)	Total (cu. ft.)
2	45.0	....	....	.....	.....
3	25.0	2.5	....	.....	.....
4	22.5	12.5	....	.....	.....
5	35.0	87.5	61.3	175.0	236.3
6	20.0	155.0	71.6	496.0	567.6
7	25.0	95.0	132.8	444.6	577.4
8	12.5	20.0	95.3	118.0	213.3
9	....	2.5	....	19.9	19.9
10	2.5	....	32.5	.....	32.5
Total	187.5	375.0	393.5	1,253.5	1,647.0

*Volumes are based on Table 5 in Gevorkiantz and Olsen (1955), adjusted to stand characteristics and converted to cubic feet.

The average height of all jack pine in the stand is 40.8 feet; that of all white pine is 33 feet. Statistical evaluation showed this difference to be highly significant. However, for the dominant stand only, the white pine is taller than the jack pine (41.8 feet compared to 40.8 feet), although not significantly so.

There are only 97 dominant and co-dominant white pine per acre, as compared to 375 dominant and co-dominant jack pine. The average d.b.h. for the dominant stand does not differ appreciably (white pine, 6.3 inches; jack pine, 6.1 inches), but there is a significant difference in the average d.b.h. for the entire stand (white pine, 5.0 inches; jack pine, 6.1 inches).

The diameter distribution of the trees (as listed in Table 3) shows a wider range for white pine than for jack pine. All jack pine trees are either dominants or co-dominants, while 48 percent of the white pine trees are in either the intermediate or suppressed crown classes. A number of white pine have died recently, as indicated by the standing dead stems.

The growth of a 10-acre pure white pine plantation in the Kellogg Forest in Kalamazoo County was evaluated. This plantation adjoins the mixed white pine-red pine plantation reported on in detail by Rudolph and Lemmien (1955). Both plantations were established in 1932. The pure white pine planting occupies a gently westerly slope, on

TABLE 4—Stand and stock table for 23-year-old white pine plantation: Kellogg Forest, Kalamazoo County, Michigan, 1955

D.B.H. (inches)	No. of trees per acre	Merch. vol. per acre (cu. ft.*)
3	5	.....
4	10	.....
5	7	7.7
6	12	27.3
7	14	45.6
8	27	113.4
9	22	139.5
10	24	196.8
11	17	163.0
12	4	46.9
13	1	14.9
14	1	16.0
Total	144	771.1

*Volumes are based on Table 5 in Gevorkiantz and Olsen (1955), adjusted to stand characteristics and converted to cubic feet.

which the soil is classified as Oshtemo loamy sand. The original spacing of the trees was 8 by 8 feet. Data for this plantation are presented in Table 4.

Poor survival in the early development of this plantation has resulted in a fairly open stand. In the past several years, a few additional trees have died from the effects of "chlorotic dwarf." In general, diameter and height growth have been good. Some of the trees have been attacked by the white pine weevil, although such injury has not been serious. The trees have large branches and full length live crowns. The average d.b.h. is 8.5 inches; the average height is 38.6 feet. Rapid trunk taper is indicated by an average form quotient[2] of 61 percent compared with a usual average of 68 percent in successful plantations of similar age. This understocked plantation has not made full use of available growing space.

SUMMARY AND CONCLUSIONS

The growth of white pine planted in mixture with red pine and jack pine in the eastern portion of the upper peninsula in Chippewa County, and in Kalamazoo County in the southwestern portion of the lower peninsula, has not been satisfactory. Developments in several such plantations at ages approximating 25 years show that the red

[2]The diameter outside bark at one-half of the total height, expressed as a percent of d.b.h.

pine and jack pine have outgrown the white pine in diameter, height, and volume.

Some white pine trees are taller than the other species in the mixtures, but their number is so small as to be unimportant in the total stand structure. Overtopping and suppression by the red pine and jack pine are continuing to reduce the white pine component in such mixtures. Past and current attacks by the white pine weevil are a contributing factor in this trend. White pine has approximately one-half the number of trees per acre, and has one-half to one-third the volume per acre of the associated species.

Pure plantations of white pine, comparable in age to the mixed plantings, and growing under similar soil and site conditions in these same areas of the state, have not developed very well either. Such plantations have shown high mortality soon after planting. They have been subjected to repeated severe attacks by the white pine weevil and increasing infestation by the white pine blister rust. Open stands are resulting in rough, limby trees, with excessive trunk taper. Attacks by the weevil and blister rust have been particularly severe in the Dunbar Forest in Chippewa County.

In both the Chippewa and Kalamazoo County locations, much better growth has been made by plantations of red pine adjacent to the pure white pine or mixed white pine-red pine and white pine-jack pine plantings. The red pine shows higher survival, freedom from insect and disease infestation, and much higher volumes per acre than white pine in pure or mixed plantings.

The desirability of using white pine for either pure or mixed plantings in these two areas of Michigan appears doubtful. This would apply also to other portions of the state with similar growing conditions. The observed development of red pine warrants its continued consideration for use in future planting programs.

LITERATURE CITED

Gaiser, R. N., and R. W. Merz (1953). Growth of planted red and white pine in Ohio and Indiana. Central States Forest Exp. Sta. Tech. Paper 138. 12 pp.

Gevorkiantz, S. R., and L. P. Olsen (1955). Composite volume tables for timber and their application in the Lake States. U. S. Dept. Agr. Tech. Bul. 1104. 51 pp.

Guise, C. H. (1945). The university forest plantations. The Cornell Plantations 1(3): 43-46.

Hicock, H. W. (1942). The Rainbow forest plantations. Conn. Agr. Exp. Sta. Bul. 464. pp. 641-645.

Rudolph, V. J., and W. Lemmien (1955). Growth of a mixed red and white pine plantation in the Kellogg Forest. Mich. Agr. Exp. Sta. Quart. Bul. 37: 412-419.

Skog, R. E. (1951). Growth of mixed red and white pine plantations in the Upper Peninsula. Mich. Agr. Exp. Sta. Quart. Bul. 34: 30-34.

Stevenson, D. D., and R. A. Bartoo (1940). Coniferous forest plantings in central Pennsylvania. Penn. Agr. Exp. Sta. Bul. 394. pp. 4-6.

"MICHIGAN MINIATURE" BROILER PRODUCTION

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OF RECENT INTEREST in the poultry industry is a new product, currently being merchandised as small "game" type broilers. Served mostly at banquets and special dinners, these birds should exhibit broad and meaty breasts and short meaty legs and thighs. A high proportion of tender breast meat is desirable in choice quality broiler chickens of any size. It is especially desirable for the small "game" type or pound-sized broilers which are destined to be served individually to gourmets.

There have been a number of recent requests for information on some of the breeding and processing problems with minature broilers. This article presents some of the results of research pertaining to the subject.

SKILLS ESSENTIAL TO PRODUCTION

The skills essential to placing such a tasty dish of chicken on the consumer's table may be listed in three categories: breeding, rearing, and processing and packaging.

BREEDING FOR MEAT TYPE MOST IMPORTANT

Plumpness of breast indicating a high proportion of white meat is primarily dependent upon breeding. The characteristic breast fullness of quail and partridge is found among certain families and breeds of chickens, notably the Cornish, or "Cornish Indian Games" as the English imports were originally designated in the United States. For miniature broiler purposes, some variety of Cornish is ideal if grown fast enough to reach the right weight (1½ pounds live) at an age when they are still tender. Broilers of superior meat type not only make an attrac-

[1]Dr. P. J. Schaible supervised feed formula composition. Mr. Eino Niemala, plant foreman, supervised the rearing procedure.

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tive dish but they yield a higher than average percentage of edible meat in proportion to bones and other waste (Henderson 1945 and 1946).

Since the growth rate of Cornish strains at 12 weeks responds to selection (Henderson, 1955a and 1955b), it seems reasonable that growth to 6 or 8 weeks would respond to selection also. The study sought to determine if rapidly grown chicks would attain good meat type at 6 or 8 weeks of age.

REARING

It was assumed that standard rearing procedures would be adequate for the production of miniature broilers. Rearing procedure should include, of course, an optimum rapid-growing "all-mash" starter feed and normal brooding temperatures.

PROCESSING AND PACKAGING

Birds of this age are very tender, and extreme care must be taken in handling and processing to be sure the skin is not torn and the bird is not bruised. A number of satisfactory slaughtering and processing methods are available. The birds may be scalded at 130° F. and most of the feathers removed by a rubber-fingered picker.

A number of short feathers and protruding pinfeathers will remain. Removing these by hand is a long, tedious job. To shorten this process, the birds can be dipped in a special wax which, when hardened and peeled, will remove the remaining protruding feathers (Drew, 1946).

Another satisfactory method to remove the feathers is to run the scalding temperature to between 140° and 145° F. After scalding, most of the feathers can be removed by a rubber-fingered picker.

After removing the feathers the birds should be cooled rapidly, then eviscerated in the conventional roaster-style manner. Birds processed in this manner should be packaged in polyethylene or other water-vapor proof material.

A very satisfactory package results when the ready-to-cook birds are placed in a small plastic bag, the air removed from the package, and the material shrunk in hot water to conform to the contour of the broiler carcass (Dewey and Almy Chemical Company, 1953).

EXPERIMENTAL EVIDENCE

THE OBJECTIVES

The objectives of the experimental work reported herein were to determine: (1) The earliest age for obtaining miniature broilers; and

(2) the proportion of chicks which might or might not qualify for the choice package at various ages. The ages selected were 5, 6 and 7 weeks.

PROCEDURE

The stock selected for this experiment consisted of 215 individually pedigreed chicks hatched November 1, 1955, and 220 chicks of approximately the same families hatched November 7, 1955.

The "breeds" selected for this test consisted of several varieties of Cornish and cross combinations with three Michigan State synthetic strains. These were: "Red Cornish" (Henderson, 1955c), "Silver Laced" Cornish (Henderson, 1952), and "Red Laced Silver" Cornish (Henderson, 1953 and 1954). Crosses were made with three Michigan State University strains of standardbred chickens; White Laced Red Cornish, White Cornish, and Red Leghorns.

The performance of the various strains and crosses with respect to the percentage of chicks that qualified as miniature broilers of superior meat type are indicated in Table 1. The Red Leghorn-Silver cross was included for comparative purposes only.

FEED AND BROODING

The standard Michigan State University all-mash starting feed was kept before the chicks at all times. Standard brooding procedures were followed.

RESULTS

Broiler growers are well aware that there is normally some variation in the age at which chicks attain a given weight. Since there are few data on meat type in conjunction with growth of chicks to very early ages, this information is recorded in Table 1.

"SHRINK" OVERNIGHT

Since the goal of miniature broiler production is assumed to be a dressed and packaged weight of as near 1 pound as possible, it is desirable to estimate "shrink" from starving prior to dressing. The data in Table 2 are for a starving period of approximately 16 hours after the live weight was recorded. It seems probable that most of the shrink in weight occurs during the first 12 hours of the "starvation" period. Average loss in weight was .11 of a pound for both males and females.

The first group of miniatures consisted largely of males. This was attributed to the more rapid growth rate of males which enabled a

TABLE 1—Percentages by breeds of miniature broilers in several meat type score classes

Breeds (abbreviated)	Number	Meat type score				
		1	2	3*	4†	5†
		Percentages				
R. C. x W. L. R.	94	22	59	28	4	0
R. C. x W. C.	140	20	53	25	2	0
R. C. x Sil. La.	82	8	32	55	4	1
Red Leg. x Sil. La.	41	0	5	57	27	11
	357					

Breed code
R. C. x W. L. R. = Red Cornish x White Laced Red Cornish (reciprocal cross).
R. C. x W. C. = Red Cornish x White Cornish (reciprocal cross).
R. C. x Sil. La. = Red Cornish x Silver Laced Cornish (reciprocal cross).
Red Leg. x Sil. La. = Red Leghorn x Silver Laced Cornish.

*Meat type about equal to the better standardbred broiler strains such as White Rocks. The minimum type acceptable as miniature broilers.
†Not considered acceptable as miniature broilers.

higher proportion of them to attain the required weight at an earlier age. Since the variability of shrink was low in the first sample, it was not considered necessary to record that information for chicks killed and dressed at 6 weeks of age.

SHRINK DURING TRANSPORT

In a sample of 136 chicks transported by truck from East Lansing to Hemlock, Michigan, the shrink was 5.3 percent. This was in addition to the loss of weight from starving for about 12 hours.

TABLE 2—Yield of miniature broilers: average live and dressed weights at two ages

No. in sample	Sexes	At 5 weeks of age			
		Live lb.	Starved lb.	Dressed package lb.	Dressing %
16	Male	1.49	1.39	1.02	68
6	Female	1.38	1.28	1.00	70
		At 6 weeks of age			
15	Male	1.63	1.50	1.09	67
21	Female	1.55	1.42	1.04	67

WEIGHT AT 5 AND 6 WEEKS

The average weights of all normal male chicks at 5 weeks was 1.32 lb. The differences between breeds were generally significant. While the least significant average difference was computed at less than one-tenth of a pound, the samples should not be considered as necessarily representative of any particular breed or cross.

It is well known that identification of sexes of chicks is difficult at the early ages of 5 and 6 weeks. A few mistakes in sexing might result in significant changes in the averages. The predominance of females in each breed category suggests that such errors were made. Chicks which were not obviously males might have been designated as females. Unfortunately, it was not possible to verify the sexes anatomically after slaughter in all lots.

In Table 3, it is obvious that the Silver Laced population "nicks" consistently better than standardbred Cornish when crossed with the Red Cornish. The M. S. U. Red Cornish strain has faster growth potential than the Silvers, however. The M. S. U. Red Cornish strain is probably not quite as rapid-growing as the most modern broiler strains of White Rocks, but it is definitely better meat type.

The Red Leghorn x Silver Laced cross grew fast enough but the percentage of good meat type broilers (Table 1) is lower than the others, as expected.

Both meat type and growth rate appear to be "quantitative" genetically. The average growth (weight) of the chicks at 5 and 6 weeks is shown in Table 3.

SEXUAL DIFFERENCE IN GROWTH RATE

The differences between the average weights of the sexes is consistent in all breeds (Table 3) and at both ages. This fact suggests that it might be worthwhile to distinguish between sexes in the purchase of chicks for broiler production.

MOST SUITABLE AGE FOR MINATURE BROILERS

The most suitable age for all factors in selecting miniature broilers from M. S. U. strains is indicated by the percentages of each brood which qualified at the several ages. About 20 percent of the first brood qualified at 5 weeks, 52 percent at 6 weeks, and 26 percent at 7 weeks. Two percent did not qualify for various reasons. In the second brood, about 50 percent qualified at 6 and the balance at 7 weeks of age. While a small percentage of miniatures can be expected among rapidly

TABLE 3—Live weights in pounds of Michigan miniature broilers at 5 and 6 weeks

Average weights at 5 weeks

Breed	No. in sample	Sexes	Ave. weight, lb.
R. C. x W. L. R.	16	Males	1.28
R. C. x W. L. R.	22	Females	1.08
R. C. x W. C.	34	Males	1.25
R. C. x W. C.	35	Females	1.14
Red L. x Sil. La.	6	Males	1.41
Red L. x Sil. La.	5	Females	1.20
R. C. x Sil. La.	12	Males	1.52
R. C. x Sil. La.	18	Females	1.31
Total	68	Males	1.32
	80	Females	1.16

Average weights at 6 weeks

R. C. x W. L. R.	48	Males	1.53
R. C. x W. L. R.	51	Females	1.30
R. C. x W. C.	69	Males	1.48
R. C. x W. C.	72	Females	1.32
Red L. x Sil. La.	17	Males	1.58
Red L. x Sil. La.	22	Females	1.36
R. C. x Sil. La.	35	Males	1.64
R. C. x Sil. La.	44	Females	1.45
Total	161	Males	1.54
	189	Females	1.35

growing strains at 5 weeks of age, it may not be the most desirable age for the average strain.

It is presumed that poor feathering and lack of meat type would be problems with very young birds in commercial processing. We are unaware of data on the ability of 5-week-old chicks to withstand mechanical picking and pinning procedures at a commercial processing plant. Six-week-old birds withstood these procedures very well, however, at the Michigan Poultry Marketing Co-op at Hemlock, Michigan.

FEED CONVERSION EFFICIENCY

Since the recording of individual feed intake is not possible under the normal brooding procedure, there is no way of measuring individual variability of this characteristic. The popular method of estimating feed conversion efficiency was used; i.e., the records of the feed consumed by pens of birds up to the several ages were obtained and averages were compiled. Since there was no mortality in Lot 1 up to the age of 5 weeks and all the chicks appeared healthy, the estimated average feed conversion ratio 2.35 is considered reasonably indicative.

At the end of the sixth week, the feed conversion ratio was 1 pound of chicken for every 2.22 pounds of feed. At 7 weeks, the ratio was 2.19; at the eighth week, it was increased to 2.82. Such an increase in ratio might be partly accounted for by the fact that about two-thirds of the thriftier chicks had been removed from each lot for slaughter by the eighth week.

SUMMARY

Some of the problems of producing and processing the new miniature (pound sized) broiler package are: Breeding for meat type; growth rate; feed conversion efficiency; yield of choice birds at various ages; dressing problems; and dressing percentage.

Recommendations for producing and processing and some pertinent experimental data are presented below.

The experimental data indicated that some variety of Cornish, or cross of proven meat type (breast width) and growth rate, was essential for the most satisfactory package. Breeding was more important than breed. The standards for selecting breeding stock must be very high.

Feed conversion efficiency varied from about 2.3 pounds to 2.8 pounds from the fifth to eighth week of age. About 20 percent of the chicks qualified at 5 weeks. The majority of the best strains took 6 to 7 weeks to reach the ideal weight of 1.5 pounds and to attain a meat type score of "3" (minimum requirement). Six- and seven-week-old chicks withstood mechanical picking. Dressing percent (live to package weight) varied from 67 to 70 percent. About 7 percent of the loss was from a 16-hour pre-dressing starvation period.

Fig. 1. The carcass on the left illustrates meat type score 1, and the carcass on the right is score 3. Note the plumpness of breast in the score 1 bird on the left.

LITERATURE CITED

Dewey and Almy Chemical Company (1953). Packaging frozen whole eviscerated poultry. Bul. C-1. 6 pp.

Drew, H. E. (1946). Wax defeathering of poultry is again on the increase. American Egg and Poult. Rev. 7(9): 18, 20, 22, and 24.

Henderson, E. W. (1945). A simple scoring system for estimating meat type of live poultry. Mich. Agr. Expt. Sta. Quart. Bul. 28: 75-81.

_____ (1946). Percentage of edible meat in relation to meat type score of chickens. Mich. Agr. Expt. Sta. Quart. Bul. 28: 176-181.

_____ (1952). A Silver-Laced chicken with Cornish ancestry. Mich. Agr. Expt. Sta. Quart. Bul. 35: 125-129.

_____ (1953). A new Red-Laced Silver mutant chicken. Mich. Agr. Expt. Sta. Quart. Bul. 36: 199-201.

_____ (1954). The genetics of a Red Laced White Mutant chicken. Proc. Tenth World Poultry Congress, Edinburgh. Part II, pp. 5-9.

_____ (1955a). Selection for growth of chickens. Mich. Agr. Expt. Sta. Quart. Bul. 37: 292-300.

_____ (1955b). Selection for growth of chickens. II. Mich. Agr. Expt. Sta. Quart. Bul. 38: 123-128.

_____ (1955c). Sample size. Mich. Agr. Expt. Sta. Quart. Bul. 38: 268-272.

RESPIRATORY ACTIVITY OF CERTAIN PLANT SPECIES AS AFFECTED BY SODIUM TRICHLOROACETATE (TCA)

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INTRODUCTION

TEMPORARY SOIL STERILANT properties of TCA have been described by Ahlgren et al. (1951), Green (1950) and Tukey (1954); its chemical and biological testing methods were worked out by Barrons and Hummer (1951). However, little information is available on the physiological action of TCA on plants.

Barrons and Hummer (1951) suggested that TCA applied to foliage readily penetrates the living cells and may react with protoplasm to bring about reduction and aberration in growth. The chemical has a contact action which is different from its systemic effects on susceptible grasses (Arnon and Machlis, 1953). It does not affect the germination of the seeds when applied to soil but the subsequent growth of the seedlings is altered and the plants usually die a few weeks after germination (Rai and Hamner, 1953). A wheat crop grown on TCA-treated soil indicated that the chemical is absorbed by the roots. The crop injury became more pronounced as the roots became more widespread (Rai, 1952).

Results obtained by Rebstock et al. (1953) demonstrated that 10- and 20-day-old seedlings grown on TCA-treated soil had a higher respiration rate than nontreated plants. They further reported that such respiratory changes are accompanied by other metabolic disturbances. The object of this paper is to report the effect of this chemical on respiratory activity of various plants and seeds.

MATERIALS AND METHODS

Applications of TCA (formulated as water-soluble sodium salt of trichloroacetic acid) at the rate of 30 pounds per acre were added to

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sandy loam soil in flats lined with wax paper to prevent leaching. Wheat (*Triticum vulgare L.*) was used as a test plant since it is sensitive to rates as low as 5 pounds per acre (Barrons, 1951). The cultures were seeded to spring wheat (var. Henry) to a depth of ½ to 1 inch in a greenhouse. The respiratory activity was determined on 1 gram of wheat foliage collected by random sampling 14 days after sowing the crop.

All respiration studies were made in a standard Warburg apparatus in 0.02 M., pH 5.7 phosphate buffer (Smith et al, 1947; Umbreit et al., 1951) by measuring the oxygen uptake.

In other experiments reported herein, plants of cauliflower (*B. oleracea L.*) and tomato (*Lycopersicon esculentum M.*) were sprayed with 5,000 p.p.m. TCA solution 4 weeks after they were transplanted in the field. Sugar beet (*Beta vulgaris L.*) and bean (*Phaseolus Spp.*) plants were also included in the test. After 7 days from the date of application, respiration studies were made on treated and nontreated plant foliage. The sample of plant tissue consisted of 1 sq. cm. discs taken from the central portion along the midrib of the leaves. Sugar beet and bean plants were 5 weeks-old at the time of sampling.

In experiments with spring wheat seeds (var. Henry), solutions of TCA, 5,000, 1,000 and 500 p.p.m. were employed to moisten the filter papers placed at the bottom of a Petri-dish containing 50 seeds each. Respiration tests were made on these seeds at intervals of 24 and 48 hours.

RESULTS AND DISCUSSION

The results presented in Table 1 indicate that TCA treatments on soil and foliage increased the respiration rate of the plant tissues studied. These results are in conformity with the observations reported by Rebstock et al. (1953).

Since application of the chemical tends to increase the rate of respiration (Rebstock et al., 1953), it is logical to assume that respiratory rates will be high in plants susceptible to TCA treatments and low in tolerant plants. On the basis of this assumption, respiratory values as reported in Table 1 indicate that tomato, cauliflower and sugar beet plants appeared to be comparatively tolerant to TCA treatments because of the low oxygen uptake of the treated plant tissue. Wheat and bean would have a lower tolerance because the respiratory ratio of the treated to control plant tissue was comparatively high (2.77 and 1.62) for these crops.

TABLE 1—Respiratory activity of the plant materials treated with sodium trichloroacetate as measured in a Warburg respirometer

Treatment	Applied to	Time observations made after treatment	Micro. liters of oxygen per hour, gram, sq. cm., or seed*		
			Non-treated	Treated	Ratio of treated to control
1. 30 lbs./A	Soil—wheat foliage	14 days	229.7	636.5/gram	2.77
2. 5,000 p.p.m.	Cauliflower foliage	7 days	35.7	50.0/sq. cm.	1.40
	Tomato foliage	7 days	29.4	40.1/sq. cm.	1.36
	Sugar beet foliage	7 days	20.3	30.7/sq. cm.	1.51
	Bean foliage	7 days	40.4	65.6/sq. cm.	1.62
3a. 5,000 p.p.m.	Wheat seeds	24 hours	9.1	7.9/seed	0.86
1,000 p.p.m.	Wheat seeds	24 hours		8.6/seed	0.94
500 p.p.m.	Wheat seeds	24 hours		14.4/seed	1.58
b. 5,000 p.p.m.	Wheat seeds	48 hours	49.4	23.3/seed	0.47
1,000 p.p.m.	Wheat seeds	48 hours		35.0/seed	0.71
500 p.p.m.	Wheat seeds	48 hours		31.3/seed	0.63

*Average of three determinations.

It is interesting to note that these results add strength to the general classification of Barrons (1951) who grouped various plant species into tolerant, intermediate and susceptible groups, depending upon their response to TCA treatments.

1. Tolerant—No effect at 5 or 10 pounds; apparent recovery from 20 pounds.
2. Intermediate—No appreciable effect at 5 pounds; apparent recovery at 10 pounds from any effect noted.
3. Susceptible—Marked effect at 5 pounds per acre and severe at higher rates.

In wheat seeds, the respiratory activity appeared to be related to the concentration of TCA solution. At high concentrations (5,000 and 1,000 p.p.m.) there was a decrease in oxygen uptake by the seeds; 500 p.p.m. treatments caused a slight stimulation in respiration. However, observation recorded 48 hours later showed a decrease of respiratory activity in all of the treatments.

It appears that low oxygen uptake in wheat seeds treated with high concentration of TCA may be due to the toxicity of the compounds and its consequent effect on the biochemical processes occurring within the seeds. However, observations recorded 24 hours

after the treatment showed that TCA solution at low concentration did not affect the wheat seeds in the same manner as the high concentrations did.

SUMMARY

1. TCA applications to soil at the rate of 30 pounds per acre caused an increase in the respiration of wheat foliage grown on treated soil.

2. Foliar applications of 5,000 p.p.m. TCA solution to tomato, cauliflower and sugar beet plants gave a lower respiratory value as compared to bean, thereby indicating that bean was the least tolerant plant in the group.

3. Observations recorded 24 hours after the treatment showed that wheat seeds treated with TCA at 5,000 and 1,000 p.p.m. showed a decrease in respiratory activity, but 500 p.p.m. treatment caused slight stimulation in respiration. However, observations recorded after 48 hours indicated a low oxygen uptake in all the treatments.

LITERATURE CITED

Ahlgren, G. H.; G. C. Klingman and D. E. Wolf (1951). *Principles of Weed Control.* John Wiley and Sons, New York. 368 pp.

Arnon, D. E., and L. Machlis (1953). *Annual Review of Plant Physiology.* Annual Reviews Inc., Stanford, Calif. 453 pp.

Barrons, K. C. (1951). Relative tolerance of crops to sodium TCA 90 percent. Down to Earth 6: 8-9.

_____, and R. W. Hummer (1951). Basic herbicidal studies with derivates of TCA. Agricultural Chem. 6 (6): 48-50, 113-121. Dow Chemical Co., Midland.

Green, K. R. (1950). TCA a promising new weedicide for grass control. Agr. Gaz. N.S. Wales 61: 455-456.

Rai, G. S. (1952). The herbicidal action of sodium trichloroacetate with special reference to *Triticum vulgare* L. Thesis for degree of Ph.D , Mich. State Univ., East Lansing. 68 pp.

_____ and C. L. Hamner (1953). Persistence of sodium trichloroacetate in different soil types. Weeds 11: 271-279.

Rebstock, T. L.; C. L. Hamner, R. W. Luecke and H. M. Sell (1953). The effect of sodium trichloroacetate upon the metabolism of wheat seedlings (*Triticum vulgare* L.). Plant Physiol. 28: 437-442.

Smith, F. G.; C. L. Hamner and R. F. Carlson (1947). Changes in food reserves and respiratory capacity of bindweed tissues accompanying herbicidal action of 2,4-dichlorophenoxy acetic acid. Plant Physiol. 22: 58-65.

Tukey, H. B. (1954). *Plant Regulators in Agriculture.* John Wiley and Sons, Inc., New York. 269 pp.

Umbreit, W. W.; R. H. Burris and J. F. Stauffer (1951). *Manometric Techniques* and tissue metabolism. Burgess Publishing Co., Minneapolis. 227 pp.

RELATIONSHIP OF STARCH GRAIN SIZE TO SPECIFIC GRAVITY OF POTATO TUBERS[1]

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SPECIFIC GRAVITY OF THE TUBER is one of the accepted measures of mealiness of the cooked potato. It is closely associated with the total solids of the tuber and, since starch is the major variable fraction of the total solids, with the starch content of the tuber. The starch, however, is in the form of discrete starch grains of a considerable range in size. The proportion of these various sizes of starch grains found in potato tubers may be directly related to the specific gravity. To test this assumption, an experiment was set up to study the proportion of various sized starch grains in potatoes of different specific gravities.

REVIEW OF LITERATURE

Clark et al. (1940) suggested that specific gravity was a practical method for making a preliminary selection for mealiness. Freeman (1942) found a significant correlation between the specific gravity of a tuber and the mealiness of its texture when baked, as indicated by a "toluene index."

According to Burton (1948) VonScheele et al. found positive correlations in potatoes between: (1) contents of dry matter and of starch; (2) the specific gravity and the content of dry matter; and (3) specific gravity and the content of starch. Briant et al. (1945) found a negative correlation between the mealiness of a cooked potato and the proportion of starch grains with a diameter of less than 0.02 mm. in the raw tuber. He indicated that the degree of mealiness of a cooked potato may be associated with the physical properties of the starch of the raw tuber.

[1]Paper presented at the Thirty-ninth annual meeting of the Potato Association of America, Michigan State University, East Lansing, Michigan; September 6-8, 1955.

[2]The authors gratefully acknowledge the cooperation of Dr. C. M. Harrison, Dr. D. R. Isleib, and Professor H. M. Brown in various phases of this project.

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Veselovsky (1940) concluded that the percentage of small and large starch grains should be considered a varietal characteristic, whereas the size of the grains determines the quality of starch. Stevenson (1938), examining the varieties Parnassia and Green Mountain, considered starch production to be the behavior of a genetic character, in the development of which environment is as important as the genetic factor.

MATERIALS AND METHODS

Six varieties of potatoes were grown at two locations in Emmet County, Michigan, in 1954. The plots were replicated three times at one place and four times at the other. The varieties grown at both locations were Cherokee, Early Gem, Kennebac, Russet Rural, Sebago and seedling 1363. The crop was planted the third week of May and was harvested the first week of October.

A 10-pound sample from each plot was taken at harvesting time, stored at 55° until the end of November, and then kept at 40° to 42° F. The samples were tested in January 1955, after being conditioned for 15 days at room temperature. Thirty-three samples from the trials were examined.

From each sample, 10 tubers approximately 2 to 2½ inches in diameter were taken for the specific gravity test. Five of the tubers were cut in half; scrapings, made with a scalpel, were composited and put on a slide with a drop of distilled water. This material was stained with potassium iodide—iodine solution. The stained slide was placed on a vertical projection microscope and the image examined on the ground glass back of a camera.

An ocular with an inserted micrometer was used for measuring the sizes of the starch grains. A card with an aperture of 1 inch by 1 inch was placed on the top of the ground glass camera view finder to standardize the area observed. The starch grains showing in this 1 inch by 1 inch opening were classified into one of the following four sizes:

Size 1—large	above 75 microns	Fig. 1
Size 2—medium	50 to 75 microns	Fig. 2
Size 3—small	25 to 50 microns	Fig. 3
Size 4—very small	less than 25 microns	Fig. 4

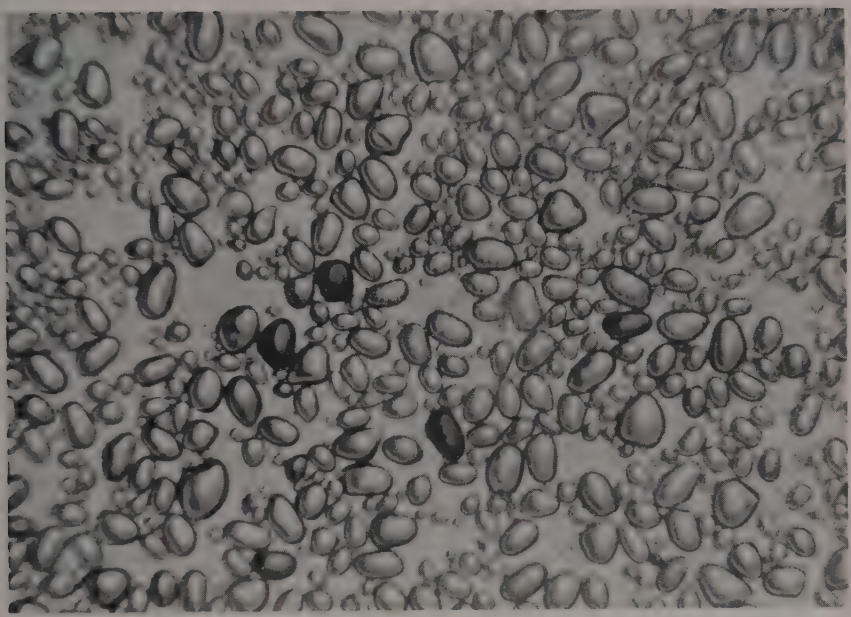

Fig. 1. Potato starch grains × 75 Size 1 - large — above 75 microns.

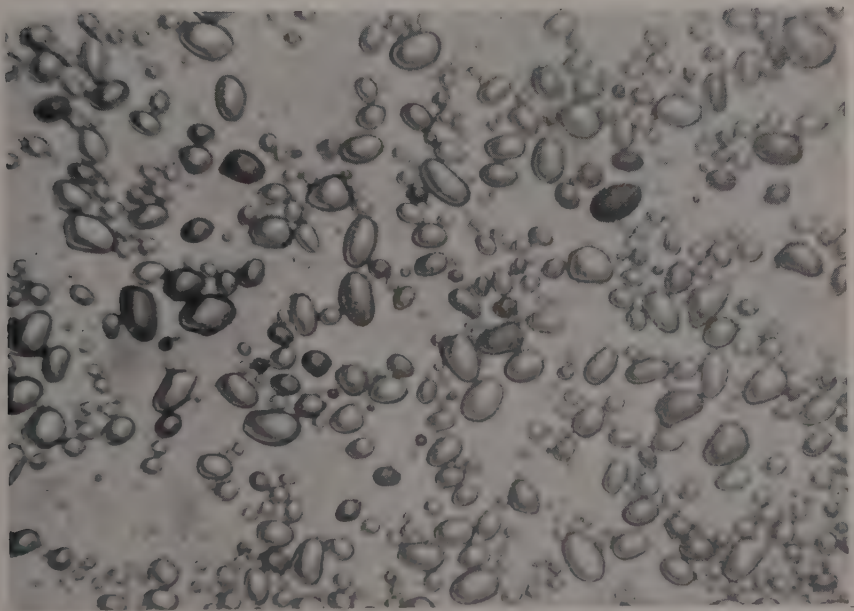

Fig. 2. Potato starch grains × 75. Size 2 - medium — 50 to 75 microns.

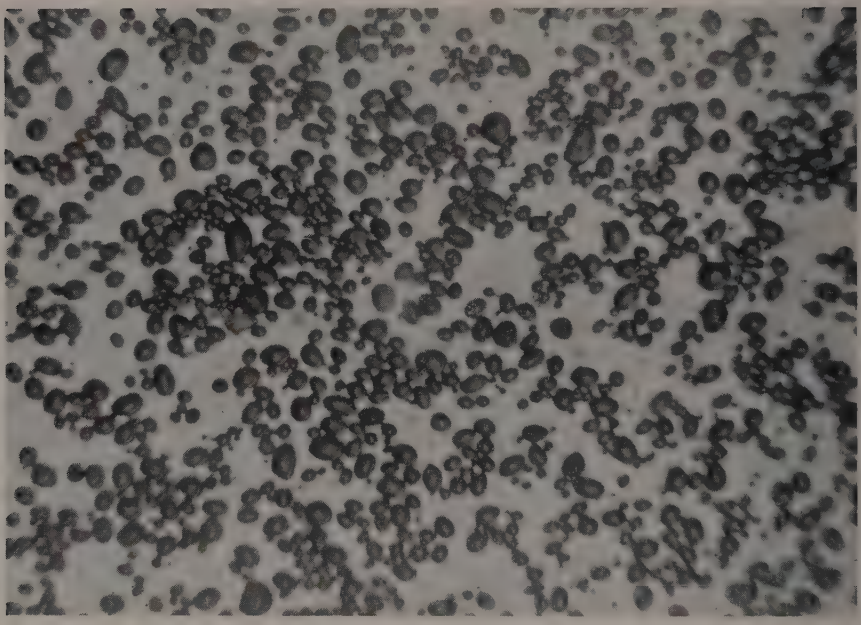

Fig. 3. Potato starch grains × 75. Size 3 - small — 25 to 50 microns.

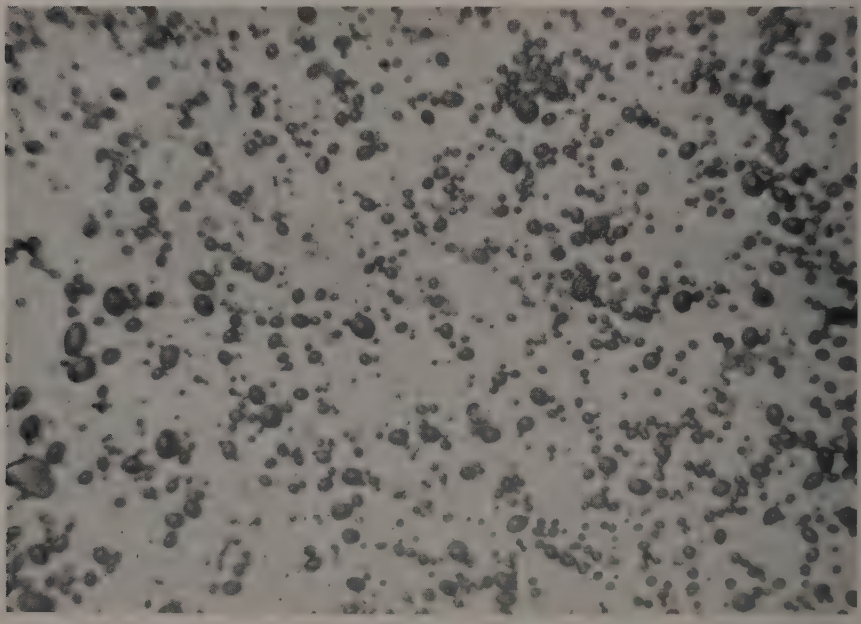

Fig. 4. Potato starch grains × 75. Size 4 - majority very small less than 25 microns.

In most instances, the entire area under observation was not covered by starch grains. As a result, the total area covered by starch grains was estimated at 100 percent, and the proportion of this total which was occupied by the starch grains of each of the above four sizes was estimated.

Five readings from different fields per slide were taken, and the average of these was used in the calculations. Linear correlation coefficients were obtained, and scattered diagrams were made to show the relationship between the specific gravity and the size of the starch grains.

RESULTS AND DISCUSSION

The total correlation coefficient of specific gravity of potatoes to the percentage of large starch grains (those above 75 microns) was positive and highly significant, ($r = + 0.782$). (See Table 1.) This showed that as the percentages of large starch grains (above 75 microns) increased, the specific gravity of the potatoes increased (Fig. 5).

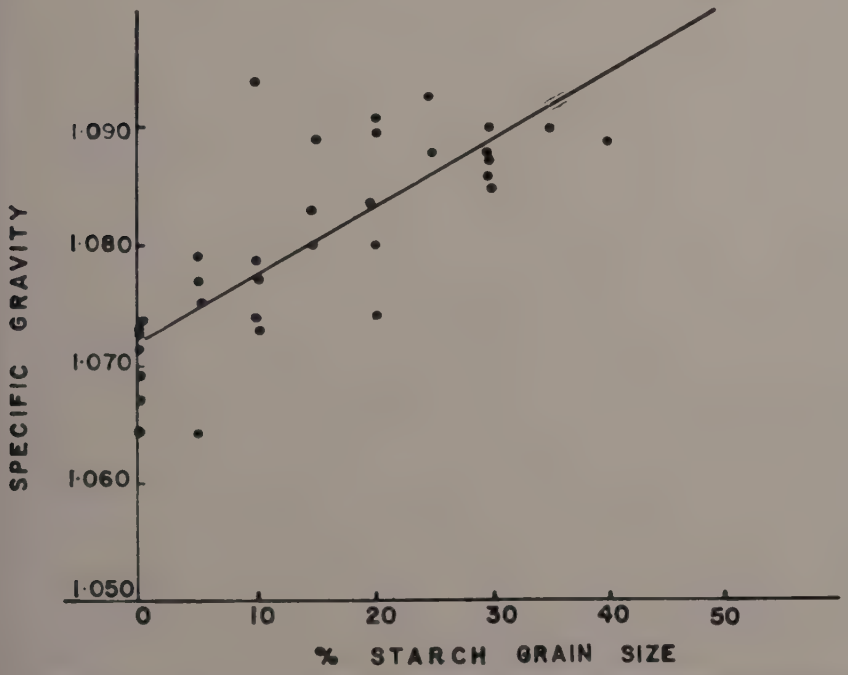

Fig. 5. Total correlation of the percentage of starch grains above 75 microns in size and specific gravity of potatoes.

$$y = 1.0803 - 0.00085 + 0.00057x$$

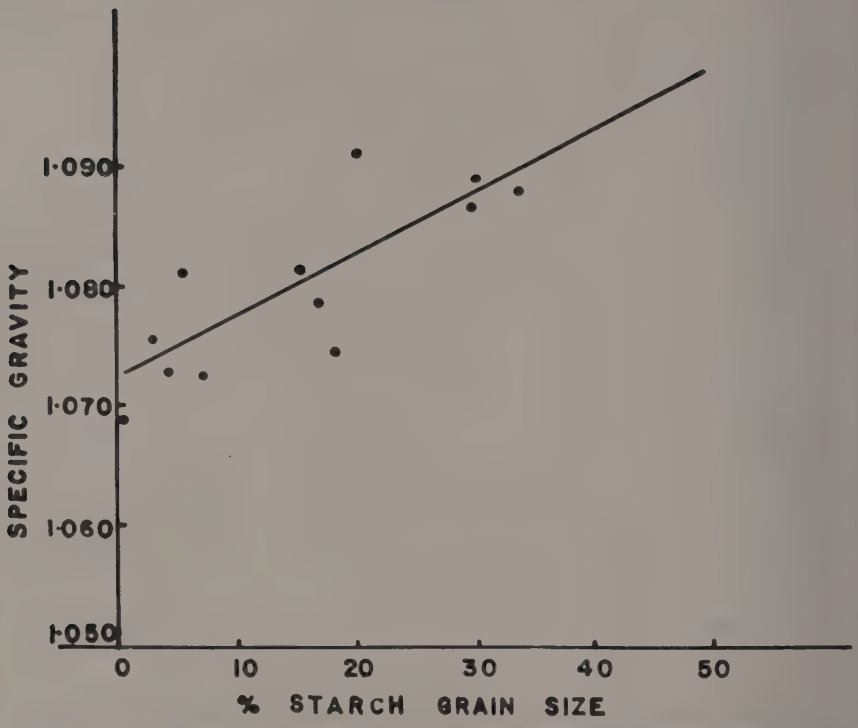

Fig. 6. Correlation of variety means of the percentage of starch grains above 75 microns in size and specific gravity of potatoes.

$$y = 1.0803 - 0.0077 + 0.00054x$$

When comparing the effect of variety means only, the correlation of specific gravity to the percentage of starch grains above 75 microns was positive ($r = + 0.82$) and highly significant. This showed that, irrespective of other factors, a variety with a high percentage of large starch grains tended to have high specific gravity (Fig. 6).

It is apparent from Table 1 that Early Gem and seedling 1363 contained low percentages of large starch grains and were low in specific gravity, while Russet Rural contained a higher percentage of large-size starch grains and was high in specific gravity.

Eliminating the effect of variety by using the deviations from variety means, it was found that there was a significant positive correlation ($r = + 0.81$) between specific gravity and percentage of large starch grains (Fig. 7). This shows that the percentage of starch grains above 75 microns increased as the specific gravity of tubers increased regardless of variety.

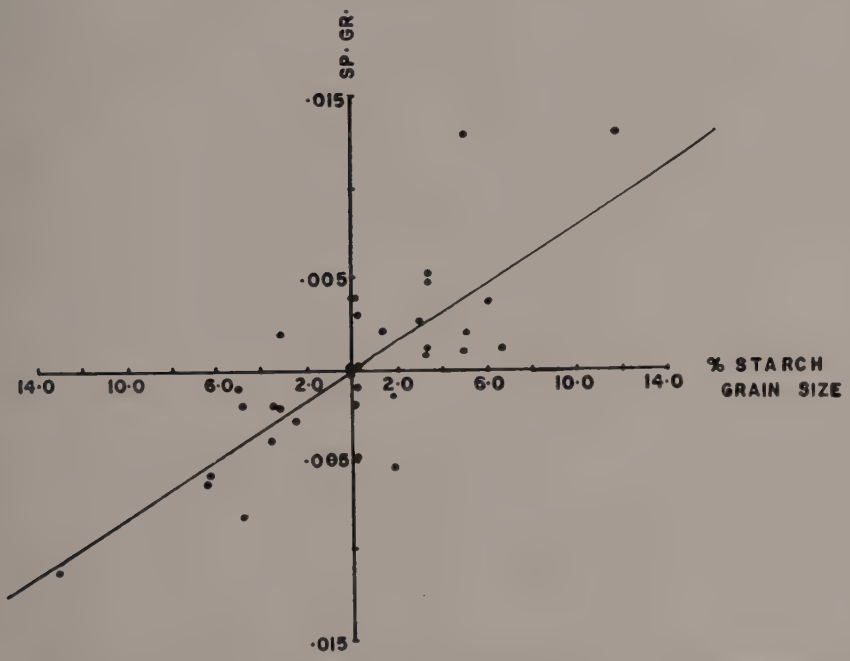

Fig. 7. Correlation of deviations from variety means of the percentage of starch grains above 75 microns in size and specific gravity of potatoes.

$$y = 0.00006 + 0.000005 + .00087x$$

Therefore, whether judged by simple plot data, by variety means or by deviations from variety means, the sample with the highest number of large starch grains (above 75 microns) had the highest specific gravity.

There was no correlation between specific gravity and the percentage of starch grains in either the size from 50 to 75 microns or the size 25 to 50 microns. Thus, these sizes had no consistent effect on specific gravity.

There was a highly significant negative coefficient of total correlation of specific gravity of potatoes to the percentage of starch grains below 25 microns in size ($r = 0.765$). (See Table 1.) The scatter diagram shows that as the percentage of starch grains below 25 microns in size increased, the specific gravity of the potatoes decreased (Fig. 8).

The same negative relationship was found between specific gravity and the percentage of starch grains below 25 microns in size for

TABLE 1—Percentage of strach grain sizes and specific gravity of samples of six varieties of potatoes grown at two locations in Michigan in 1954

Location	Variety	Repl.	Starch grain sizes				Average specific gravity of 10 tubers
			1	3	3	4	
I	Russet Rural....	1	40	30	15	15	1.089
		2	30	45	15	10	1.090
		3	30	35	25	10	1.086
		Mean	33.3	36.7	18.3	11.6	1.088
	Sebago.....	1	10	30	30	30	1.073
		2	20	25	35	20	1.080
		3	20	25	25	30	1.084
		Mean	16.7	26.7	30.0	26.7	1.079
	Kennebec.....	1	30	30	20	20	1.088
		2	20	25	20	35	1.074
		3	5	30	20	45	1.064
		Mean	18.3	28.3	20	33.3	1.075
	Cherokee.....	1	10	30	30	30	1.094
		2	5	25	30	40	1.077
		3	0	30	30	40	1.073
		Mean	5.0	28.3	30	36.7	1.081
	Seedling 1363....	1	0	30	20	50	1.067
		2	10	25	20	45	1.074
		3	10	30	20	40	1.078
		Mean	6.7	28.3	20	45	1.073
	Early Gem.....	1	0	5	30	65	1.064
		2	0	10	35	55	1.073
		Mean	0.0	7.5	32.5	60	1.069
II	Russet Rural....	1	30	35	20	15	1.086
		2	30	30	20	20	1.087
		Mean	30	32.5	20	17.5	1.087
	Sebago.....	1	5	30	30	35	1.075
		2	0	30	35	35	1.071
		3	0	25	30	45	1.069
		4	10	25	25	40	1.077
		Mean	3.8	27.5	30.0	38.8	1.073
	Kennebec.....	1	35	35	15	15	1.090
		2	25	35	20	20	1.088
		Mean	30.0	35	17.5	17.5	1.089
	Cherokee.....	1	20	20	30	30	1.091
		2	15	25	30	30	1.089
		3	25	25	25	25	1.093
		4	20	25	25	30	1.091
		Mean	20	23.7	27.5	28.8	1.091
	Seedling 1363....	1	15	30	30	25	1.080
		2	15	25	30	30	1.083
		Mean	15	27.5	30	27.5	1.082
	Early Gem.....	1	0	10	35	55	1.073
		2	5	5	40	50	1.079
		Mean	2.5	7.5	37.5	52.5	1.076

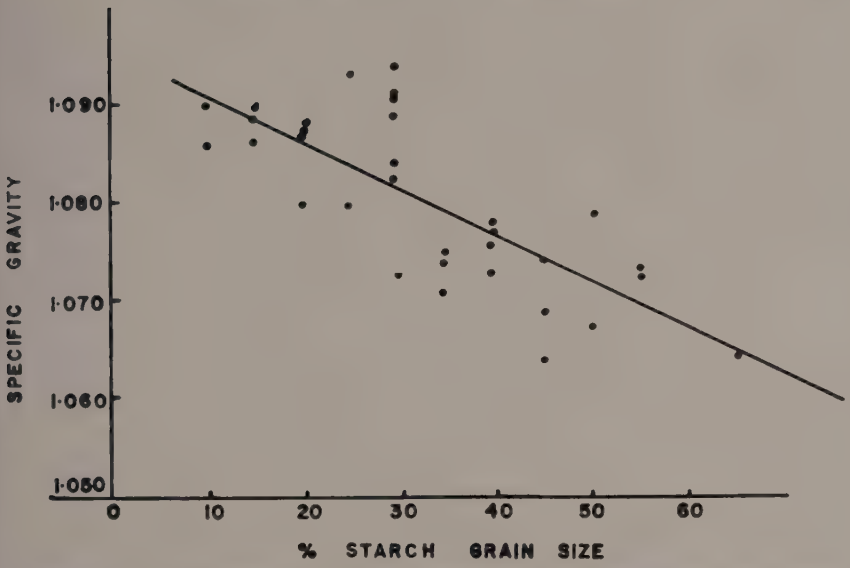

Fig. 8. Total correlation of the percentage of starch grains below 25 microns in size and specific gravity of potatoes.

$$y = 1.0803 + 0.01577 - 0.00048x$$

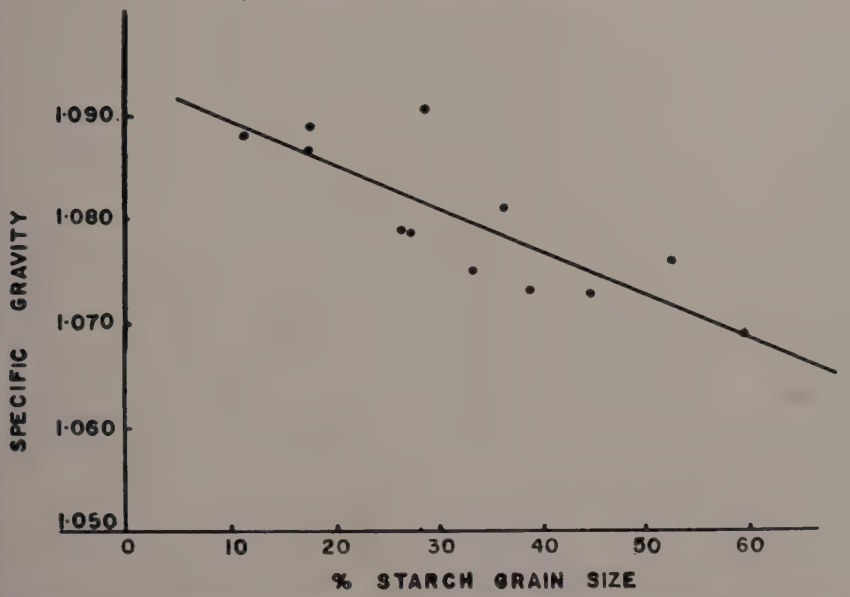

Fig. 9. Correlation of variety means of the percentage of starch grains below 25 microns in size and specific gravity of potatoes.

$$y = 1.0803 + 0.01382 - 0.00042x$$

variety means (Table 1). The correlation coefficient, r = — 0.833 was highly significant. This showed that varieties affected the size of starch grains (Fig. 9). It would appear that the size of the grains was a varietal characteristic. From Table 1 it is clear that Russet Rural, with the lowest percentage of starch grains (below 25 microns), had high specific gravity; and Early Gem, with the highest percentage of starch grains below 25 microns, had the lowest specific gravity.

A highly significant negative correlation (r = — 0.76) was also found between the specific gravity and the percentage of starch grains below 25 microns in size when using the deviations from the variety means (Fig. 10). Therefore, when the varietal effects were removed, the specific gravity varied inversely with the percentage of small-size starch grains.

It is evident from the scatter diagrams of the simple plot data, of the variety means and of the deviations from the variety means, that the higher the percent of starch grains below 25 microns in size, the lower the specific gravity.

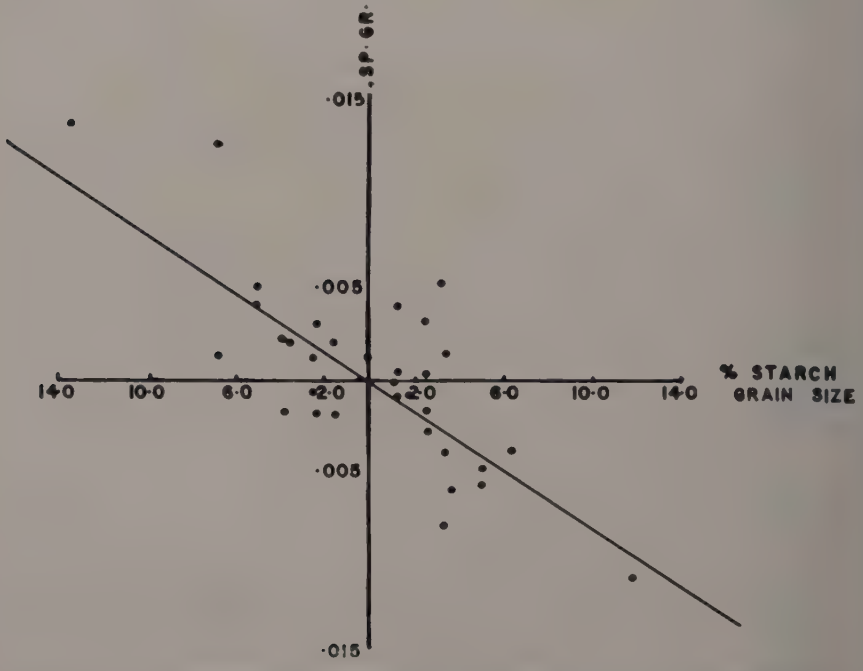

Fig. 10. Correlation of deviations from variety means of the percentage of starch grains below 25 microns in size and specific gravity of potatoes.

$$y = 0.00006 - 0.000007 - 0.00081x$$

SUMMARY AND CONCLUSIONS

The proportion of the various sizes of starch grains in a potato tuber is related to the specific gravity.

The percentage of large starch grains (above 75 microns) and very small starch grains (below 25 microns) affected the specific gravity of the potato.

In these tests, intermediate starch grains (between 25 and 75 microns) had no consistent effect on the specific gravity.

The higher the proportion of large starch grains (above 75 microns), the higher the specific gravity.

The relative composition of potato starch, namely the percentages of small and large grains developed under a common environment, may be a varietal characteristic.

LITERATURE CITED

Briant, A. M.; C. J. Personus and E. G. Cassel (1945). Physical properties of starch from potatoes of different culinary quality. Food Res. 10: 437-444.

Burton, W. G. (1948). *The Potato.* Chapman and Hall. 284 pp.

Clark, C. F.; P. M. Lombard and E. F. Whiteman (1940). Cooking quality of the potato as measured by specific gravity. Amer. Potato Jour. 17: 38-45.

Freeman, M. E. (1942). Measurement of texture in baked potatoes tissue. Food Res. 7: 451-458.

Stevenson, F. J. (1938). Starch content in potatoes. Amer. Potato Jour. 15: 356-357.

Veselovsky, I. A. (1940). Biochemical and anatomical properties of starch of different varieties of potatoes and their importance for industrial purposes. Amer. Potato Jour. 17: 330-339.

AN INVESTIGATION OF SOME FACTORS AFFECTING THE DISTILLATION OF PEPPERMINT OIL

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OIL IS REMOVED from peppermint hay by a process of steam distillation. The pounds obtained per acre are the criteria of yield, but the ratio of the amount of hay produced to the amount of oil recovered is not constant.

The standard practice in the distillation of peppermint oil is to field cure the hay prior to the distillation operation. During periods of rainy weather, the time required for the curing process may extend to a week or more. The yield and quality of oil is generally reduced when this weather situation is encountered. One of the objectives of the curing process is to reduce the moisture content of the hay so that less steam is required for removal of the oil.

Inaccuracies beyond chance variance in the recovery of peppermint oil from the hay produced on the University Muck Farm experimental plots was responsible for the initiation of this investigation.

The study was divided into three parts:

Installation of the distillation plant.

Evaluation of the efficiency of the apparatus.

Study of some factors associated with efficient distillation procedures.

INSTALLATION AND EVALUATION OF A DISTILLATION PLANT

The installation includes four basic pieces of equipment: (a) a boiler to provide steam, (b) tubs to receive peppermint hay, (c) condensers to liquefy the mixture of steam and peppermint oil vapor,

[1]The authors gratefully acknowledge the valuable help given by Dr. J. F. Davis of the Department of Soil Science in planning and carrying out this work.

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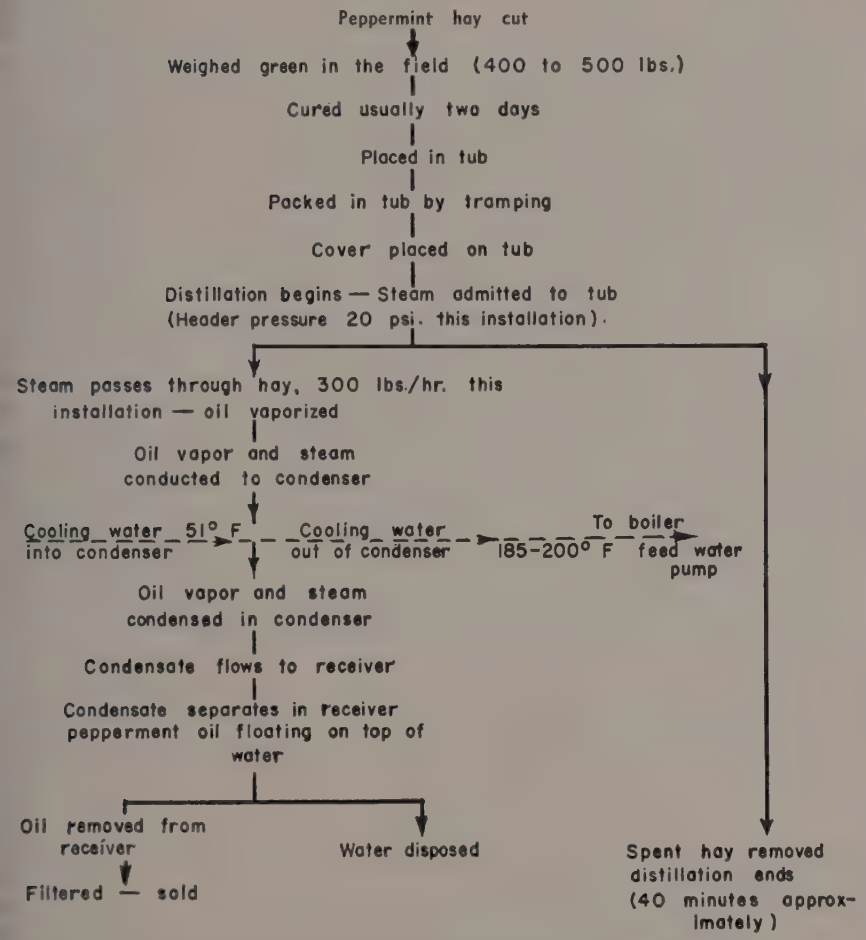
Peppermint hay cut
Weighed green in the field (400 to 500 lbs.)
Cured usually two days
Placed in tub
Packed in tub by tramping
Cover placed on tub
Distillation begins — Steam admitted to tub
(Header pressure 20 psi. this installation).
Steam passes through hay, 300 lbs./hr. this installation — oil vaporized
Oil vapor and steam conducted to condenser
Cooling water into condenser 51° F
Cooling water out of condenser
To boiler feed water pump 185-200° F
Oil vapor and steam condensed in condenser
Condensate flows to receiver
Condensate separates in receiver pepperment oil floating on top of water
Oil removed from receiver
Filtered — sold
Water disposed
Spent hay removed distillation ends (40 minutes approximately)

Fig. 1. Product flow diagram of the experimental distillation plant.

and (d) receivers to separate the water and oil distillate (Fig. 1). The information and recommendations published by Oregon State College (Hughes, 1952) were generally followed in making the installation.

BOILER

The boiler was an oil-fired vertical fire-tube type with a heating surface of 219 square feet and a working pressure of 100 pounds per square inch (p.s.i.). Pressure, water level, and combustion were controlled automatically by a pressure-operated switch, float-operated

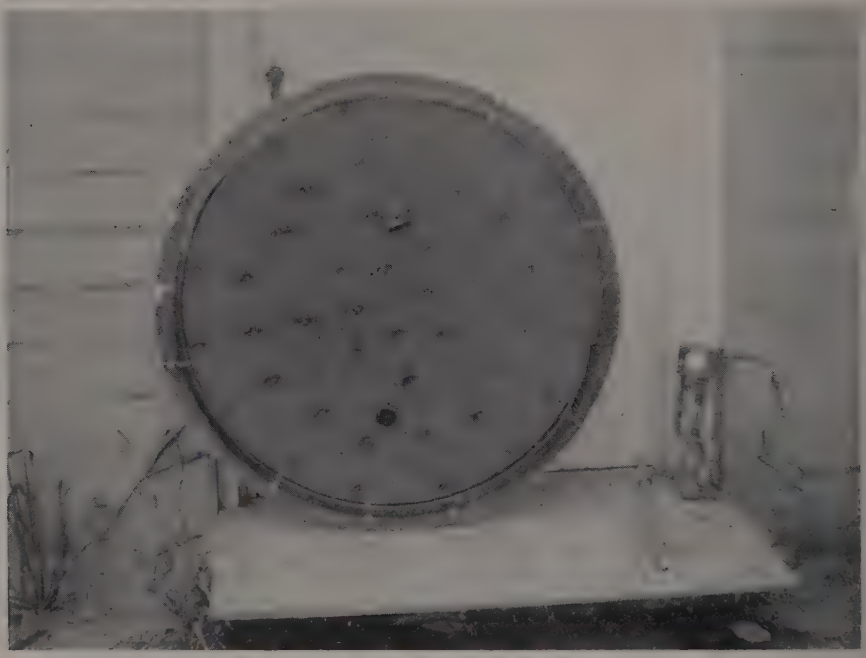

Fig. 2. Plywood top and plastic hose for seal.

mercury switch and a diaphragm-operated switch, respectively. When these devices become defective they "fail safe".

TUBS

Two stainless steel dairy processing tubs[2] having a capacity of 150 gallons each and big enough to hold 500 pounds of green peppermint hay were used for the distillation tubs. The bottom of each tub was fitted with a 10 gauge steel floor perforated with ⅛-inch holes to disperse the steam through the hay. A 4-inch hole was drilled in the side of each tub 2 inches below the top to provide an outlet for the mixed steam and mint oil vapor. A 4-inch aluminum irrigation pipe was used to conduct the vapor to the condensers.

Tub covers of marine plywood ¾ inch thick have given satisfactory service and have not shown signs of deterioration in 2 years from the action of the steam, mint vapor, or weathering. A vinyl plastic garden hose cut to the proper length and laced together with a piece of plastic clothesline cord provided an effective seal between the

[2]Appreciation is expressed to the Creamery Package Manufacturing Company, Chicago, for furnishing two 150-gallon stainless steel dairy processing tanks.

cover and tub. Pieces of plastic cord were used to hold this gasket in position on the lid (Fig. 2). Gaskets cut from the plastic hose also made satisfactory seals for the temperature and pressure fittings at the joints of the tub outlet and condenser inlet.

CONDENSERS

Two vertical aluminum straight tube condensers were used, each with a capacity of 1,200 pounds of steam per hour. The temperature of the distillate was controlled at 110 to 120° F. A sensing element in the condensate drain pipe actuated a bellows-type control valve which regulated the rate of flow of the condenser-cooling water.[3] A jet-type condenser was tested, using a garden hose nozzle to regulate the jet of cold water. It performed satisfactorily for condensing the mixture of steam and mint vapor. However, too much turbulence in the receiver caused 80 percent of the oil to be lost at the receiver drain.

RECEIVER

The receivers were made according to recommendations contained in the Oregon State publication (Hughes, 1952). The 1½-inch diameter tail pipes from the condensers to the receivers were provided with return bends to facilitate oil separation (Fig. 3). These allowed the operator to observe when the oil either started or stopped flowing.

INSTRUMENTATION

Pressure gauge fittings and thermometer wells placed in the entrance to the tub, tub cover, vapor conducting pipe (tub outlet and condenser inlet) and condenser permitted the operator to obtain information concerning the performance of the still. By recording the readings of these instruments periodically, a record of performance of the apparatus was obtained for future reference.

PROCEDURE

The variation in recovery of peppermint oil from hay is considerable. Any variation in the amount of oil recovered might be attributed to either variation of oil in the hay or a lack of consistency in the performance of the apparatus used in separating the oil from the hay.

The efficiency and consistency of recovery of oil by the still was determined by the oil-on-water method. This procedure consisted of

[3]Temperature regulator No. 999 of the Fulton Sylphon division of Robertshaw-Fulton Controls Company was used for regulating the rate of flow.

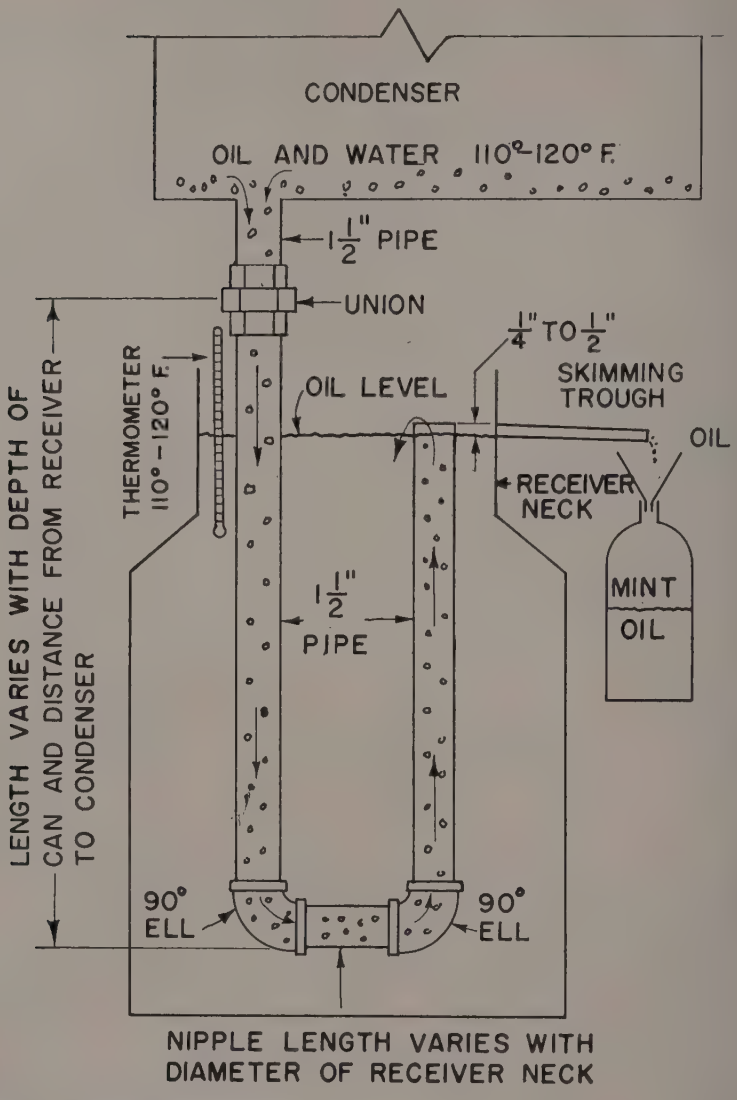

Fig. 3. Design of the receiver.

placing a known amount of oil on the water in the tub and measuring the amount of oil recovered in the receiver (Table 1).

In 1955, an operational experiment was conducted in which nine 500-pound samples of green hay were taken at random from a uniform stand of meadow mint. Two of the samples were distilled immediately after cutting . Three of the samples were cured for 2 days, one sample

TABLE 1—Oil recovery in the distillation apparatus by oil-on-water method (Kahl, 1955)

(Each sample number represents four tests)

Sample number	Steam flow (lb./hr.)	Time (min.)	Amount of oil in tubs (grams)	Loss, percent	$\bar{X}$	R
1	319	40	442	15.9	15.9	14.1
2	300	42	773	9.8	9.8	4.9
3	288	41	879	8.3	8.3	6.5
4	309	41	885	9.2	9.2	5.6
5	328	40	875	8.2	8.2	3.6
6	187	55	1109	7.5	7.5	6.1
7	250	50	1317	5.8	5.8	3.7
8	250	45	1319	6.3	6.3	2.3
9	250	40	1744	5.5	5.5	8.7
10	250	40	1757	4.8	4.8	1.2
11	250	40	1103	4.7	4.7	2.9
12	250	40	549	9.9	9.9	7.9
13	469	40	1771	11.6	11.6	8.7
14	406	40	1436	5.1	5.1	6.8
15	250	57	899	8.6	8.5	3.0
16	194	49	1668	8.2	8.2	14.9
17	300	40	1764	5.1	5.1	9.5
18	288	42	1000	8.6	8.6	6.7
19	300	40	1000	6.3	6.3	1.8
20	300	42	1000	7.6	7.6	6.4
21	300	41	1000	7.8	7.8	5.0

for 3 days, and three samples for 4 days. The average distillation time was 160, 120, 50 and 50 minutes, respectively, for the hay from the four curing treatments (Table 2). Temperatures slightly in excess of 90° F. were experienced during the field curing time, and precipitation did not occur during this time interval. The oil samples were analyzed for esters and percent total menthol.

RESULTS

Losses ranging from 32 to 48 percent by weight were recorded as a result of vapor leaks which occurred at the tub, condenser, and piping between the tub and condenser before final plastic seals were constructed. It should be emphasized that these leaks were barely discernible. When two receivers were used in series (i.e., the first receiver discharging into the second), the presence of oil in the second receiver indicated the loss of oil from the first. Excessive steam flow and failure to warm the condenser and receiver prior to operation were the more frequent causes of oil loss.

*TABLE 2—The effect of time of curing on the composition and recovery of peppermint oil, Michigan State University Muck Experiment Farm, 1955**

	Time of distillation (minutes)	Oil† grams	Esters, percent	Menthol total, percent
Green hay.....	160	321	4.67	47.82
Cured 2 days.....	120	405	4.47	45.62
Cured 3 days.....	50	...	5.88	50.88
Cured 4 days.....	50	396	5.97	48.88

*Grams of oil expressed as averages of three replications for samples cured 2 or 4 days, two replications for the green hay, and one replication for the sample cured 3 days. Chemical composition data obtained from a composite sample of the replications.

†Grams of oil per 400 pounds of green hay. There was no precipitation on hay.

A statistical control chart, constructed by standard statistical methods, indicated whether the apparatus was operating efficiently.

The data in Table 2 show that the yields of oil from the samples cured in either 2 or 4 days were higher than the yield obtained from the uncured green hay samples. This indicates that some curing is necessary in order to obtain maximum oil yields, even though the uncured green hay samples were distilled for 160 minutes. The percent esters in the oil increased as the time for curing increased; however, there was no consistent variation in the total menthol content.

MATURITY

The effect of maturity has been reported as an important factor in determining the yield and composition of the oil. Ellis (1944) stated that as the menthol content reaches 45 percent, the yield of oil generally increases.

An area of uniform meadow mint was divided into 15 plots, each 23 feet wide and 40 feet long. The hay on three of these plots was cut on each of the following dates: July 19, 22, 25, 27 and August 1. The hay was protected from rain during the curing process. The data in Table 3 show a significant increase in yield of oil from hay cut on July 22 as compared to the hay cut July 25 and July 27, respectively. However, the yield of oil from hay cut August 1 was as high as the yield obtained from hay cut on July 22.

An increase in the yield of hay was not always accompanied by an increase in the yield of oil. The percent esters in the oil increased with an increase in the maturity of the crop. The menthol content progressively increased with the first three harvest dates (July 19, 22, 25)

and then decreased to the lowest point on July 27. These data indicate a wide variation, not only in yield of green hay and oil per acre, but also in the composition of the oil within a 2- or 3-day period. The decrease in yield of hay might be accounted for, in part, by the leaf drop that takes place as the crop matures.

Equal areas of uniform row mint were cut on nine different dates from August 22 to September 16. The samples were cured for 2 days and protected from rain throughout the curing period. As indicated in Table 3, the highest yields of hay and oil were obtained from peppermint cut September 2. As the date of harvest advanced throughout the season, the oil yield decreased from the peak yield of 28.3 pounds per acre for samples cut on September 2.

The percent of esters varied throughout the season with a tendency to increase as the crop matured. However, the percent of esters (6.97) in the oil obtained from hay cut August 22 was considerably higher than the ester content of the oil obtained from hay cut August 24 and 26, respectively.

The percent of total menthol generally increased as the maturity of the crop increased; however, it did not vary consistently with yield of oil. Peppermint hay cut August 31 yielded 18.2 pounds of oil per acre. The total menthol content of this oil was 54.23 percent. This yield was lower than that obtained August 24 when the yield and menthol content were 23.7 pounds and 43.56 percent, respectively.

The yield of oil from peppermint cut August 22 was 18.7 pounds per acre which was approximately equal to the yield from peppermint

*TABLE 3—The effect of time of harvest on the composition and yield of peppermint oil, Michigan Muck Experimental Farm, 1955**

Meadow mint					Row mint				
Date cut	Tons green hay per acre	Pounds oil per acre	Percent esters	Percent total menthol	Date cut	Tons green hay per acre	Pounds oil per acre	Percent esters	Percent total menthol
July 19...	8.6	29.9	5.14	48.30	Aug. 22	4.3	18.7	6.97	51.78
July 22	11.9	37.1	5.49	48.98	Aug. 24	4.9	23.7	4.53	43.56
July 25...	13.6	26.5	6.99	56.29	Aug. 26	4.7	20.5	6.02	48.84
July 27...	11.0	22.0	7.07	47.74	Aug. 31	5.8	18.2	8.09	54.23
Aug. 1...	8.3	37.0	....	.....	Sept. 2	7.3	28.3	6.84	53.94
L.S.D (5% level)	2.1	7.4	....	.....	Sept. 7	6.9	27.6	8.01	55.96
					Sept. 9	6.4	27.8	7.37	56.34
					Sept. 12	6.3	24.7	9.44	64.36
					Sept. 16	5.4	24.8	9.87	62.62

*Data for row mint obtained from a composite sample from two replications. Yield data from meadow mint expressed as averages of three replications. There was no precipitation on hay.

cut 9 days previously. The menthol content of this sample was 51.78 percent.

SUMMARY

The variation in the amount of peppermint oil recovered from a given weight of hay is considerable. Any variation in the amount of oil recovered might be attributed to either variation of oil in the hay or a lack of consistency in the performance of the apparatus used in separating the oil from the hay. In this study, the efficiency and consistency of recovery of oil by use of an experimental still was determined by the oil-on-water method. After the efficiency of the apparatus for recovering oil was established, a further study was undertaken to determine: (1) the effect of curing time on the amount of oil recovered, and (2) the effect of the date of cutting row and meadow mint on the yield and composition of the oil.

The findings of the studies were as follows:

1. The average recovery of peppermint oil in the distillation process was 92 percent after all leaks in the system were effectively stopped.
2. A steam flow of 250 to 400 pounds per hour gave the best results for the experimental still.
3. Curing hay 3 to 4 days reduced the required distillation time about one-third, and the increase in oil recovered was about one-fourth above that from the green hay.
4. Oil recovery from peppermint hay cured 2 days was high, but the time required for distillation was more than twice that required for hay cured 3 or 4 days.
5. An optimum time for harvesting peppermint is indicated since the oil yield increases with maturity to an optimum and decreases after the optimum harvest date has passed.

REFERENCES

Burr, Irving W. (1953). *Engineering Statistics and Quality Control.* McGraw-Hill Book Co., New York.

Committee of board of trustees (1950). *Pharmacopeia of the United States.* 14th rev. Mack Publishing Co., Easton. pp. 442-444.

Ellis, N. K.; L. J. Swift and M. H. Thornton (1944). A method of telling the time of cutting peppermint for highest oil yield. Purdue Univ. Dept. of Horticulture Mimeo. No. 3. 3 pp.

Hughes, A. D. (1952). Improvements in the field distillation of peppermint oil. Oregon State Engineering Expt. Sta. Bul. 31. 64 pp.

Kahl, W. H. (1955). Installation and evaluation of an experimental peppermint oil distillation plant. Thesis for degree of M.S., Mich. State Univ., East Lansing. (Unpublished)

COLD STORAGE OF CUT TULIPS WITH AND WITHOUT WATER

By GERHARD BÜNEMANN and D. H. DEWEY
DEPARTMENT OF HORTICULTURE

THE PRACTICAL APPLICATION of low temperature for the storage of cut flowers without water in closed moisture-proof containers has been developed by Fischer (1953), and dry storage recommendations for a number of cut flowers have been made by Post and Fischer (1952). These workers stored freshly harvested flowers of tulips in sealed drums for 8 weeks at 31° F. Von Oppenfeld et al. (1955) showed that flowers cut from tulips grown in the field could be satisfactorily stored for 5 and 6 weeks in packages overwrapped and sealed with plastic film.

Flowers in sealed containers, however, may be damaged by the accumulation of gaseous carbon dioxide, or the depreciation of oxygen. Van Stuivenberg (1946, 1949) reported carbon dioxide caused a geotropic bending of tulip flower stems; and concentrations in excess of 5 percent at storage temperatures of 34 to 50° F. were injurious to the three varieties he studied.

The flowers stored by von Oppenfeld et al. (1955) were not injured during 5 weeks of storage at 32° F. even though the carbon dioxide reached 15 percent and the oxygen was depleted below 1 percent in the sealed packages. Upon longer storage, however, tulips were injured by carbon dioxide in excess of 7 percent under conditions in which the oxygen was maintained to give a carbon dioxide and oxygen total of about 21 percent.

Cut flowers of tulips also have been stored in the open with the stems in water. By this method Whiteman et el. (1934) held tulips in a salable condition for 35 days at 32° F. Blooms of the variety Feu Brillant were in good condition after 4 months with this method, but were unsalable upon removal from storage because of their short shelf-life at room temperatures.

Further investigation of the storage rèquirements of cut flowers of tulips was desirable because of these variable results. The purpose

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of this study was to ascertain the suitable levels of carbon dioxide and oxygen for flowers stored without water in sealed containers at several storage temperatures, and to compare this type of storage with storage of flowers in the open with the stems in water.

METHODS AND MATERIALS

Flowers of the variety William Copland, commercially field-grown near Kalamazoo, were harvested the morning of May 2, 1955, with the petals opened slightly. The stems were cut between the first and second leaf and bound with rubber bands in lots of 1 dozen flowers. They were transported to East Lansing the same day in closed bulk shipping boxes and stored overnight without water at 40° F. The following day, 16 dozen flowers were placed horizontally in metal drums of 30-gallon capacity for storage at 31, 40 and 50° F.

Controlled atmospheres of variable proportions of carbon dioxide and oxygen were maintained in the closed drums (Table 1). These atmospheres were established initially and again after each periodic removal of flowers by flushing the excess oxygen from the chambers with nitrogen and adding gaseous carbon dioxide. The levels of gas within the drums were determined daily with a Hayes Orsat analyzer and readjusted to the desired concentrations by adding air, nitrogen, or carbon dioxide. A small quantity of water was provided at the bottom of the closed chambers as an aid in maintaining a high humidity.

Control flowers without water were held at the same temperatures in closed drums which were supplied with a constant flow of fresh, humid air. Other flowers were stored in the open with stems held upright in water in receptacles in the same experimental cold storage rooms.

The flowers were stored for periods of 2, 4, 6 and 8 weeks duration. Upon removal from cold storage, the flower stems were recut and placed in warm water (100-105° F.); the flowers were then stored with their stems in water for 24 hours at 40° F. Following this "hardening" treatment, they were held in water at 72° F. for evaluation of shelf-life at room temperatures.

Weight, stem length, condition of petals, leaves and stems, and petal color of four samples of a dozen flowers for each test condition were recorded at harvest and after storage. The Horticultural Colour Charts published by the British Colour Council (1941) served for estimating the color changes of the petals. The color comparisons were

TABLE 1—Temperatures and atmospheres used for the storage of William Copland tulip flowers without water in closed chambers

Temperature (°F.)	Desired atmosphere		Average atmosphere			
	(Gas)	(%)	May 3-17 (%)	May 18-31 (%)	June 1-14 (%)	June 15-28 (%)
31	CO_2	11	11.2	10.2	10.7	10.1
	O_2	10	13.1	8.3	11.9	12.7
	CO_2	16	13.3	14.0	13.9	14.5
	O_2	5	8.0	7.2	11.1	9.9
	CO_2	19	18.8	17.3	19.5	18.7
	O_2	2	5.0	5.1	4.1	2.2
	CO_2	21	20.3	19.7	19.5	....
	O_2	0	4.7	3.7	4.7	....
40	CO_2	11	16.8	12.2	11.6	10.7
	O_2	10	6.8	9.3	11.1	9.3
	CO_2	16	16.2	16.0	15.7	15.5
	O_2	5	6.1	5.0	8.4	4.8
	CO_2	19	17.8	17.9	18.2	....
	O_2	2	5.5	3.8	4.0	....
	CO_2	21	20.4	18.7	20.7	....
	O_2	0	2.2	2.3	4.3	....
50	CO_2	11	16.5	15.2	....	....
	O_2	10	7.9	6.2	....	....
	CO_2	16	18.0	18.3	....	....
	O_2	5	4.9	4.1	....	....
	CO_2	19	18.7	19.2	....	....
	O_2	2	3.5	4.4	....	....
	CO_2	21	20.8	21.7	....	....
	O_2	0	2.3	2.8	....	....

made under artificial light supplied by a 60-watt tungsten lamp at a distance of 12 to 16 inches.

RESULTS

The keeping quality of the flowers in terms of storage-life and shelf-life is sumarized in Table 2. The best condition of dry storage was an atmosphere of 11 percent carbon dioxide and 10 percent oxy-

TABLE 2—Condition of cut flowers of William Copland tulips stored dry in normal and modified atmospheres and in the open with the stems in water

Storage conditions		Storage life (weeks)	Shelf-life* (days)	Condition upon removal from storage and during holding at 72° F. after "hardening"
Atmosphere	Temp. (°F.)			
Normal (21% O_2, .03% CO_2), high humidity	31	2	3	Serious mold on anthers at 4 weeks; otherwise, fair condition after 8 weeks.
	40	2	3	Serious petal abscission at 4 weeks of storage.
	50	2	0	Leaves and anthers molded at 2 weeks.
11% CO_2 and 10% O_2, high humidity	31	8	2	Leaves slightly flaccid at 4 weeks; quality and petal retention fair after 8 weeks.
	40	2	3	Petals and leaves did not recover full turgidity; good retention of petals.
	50	2	0	Leaves and anthers molded at 2 weeks.
16% CO_2 and 5% O_2, high humidity	31	2	3	Petals discolored and deteriorated at 4 weeks.
	40	2	3	Petals discolored and deteriorated at 4 weeks.
	50	2	0	Leaves and petals molded, petal abscission at 2 weeks.
19% CO_2 and 2% O_2, high humidity	31	2	0	Stems, leaves and petals flaccid, petal abscission at 2 weeks.
	40	2	0	Stems, leaves and petals flaccid, petal abscission at 2 weeks.
	50	2	0	Stems, leaves and petals flaccid, petal abscission at 2 weeks.
21% CO_2 and 2% O_2, high humidity	31	2	0	Stems, leaves and petals flaccid, petal abscission at 2 weeks.
	40	2	0	Stems, leaves and petals flaccid, petal abscission at 2 weeks.
	50	2	0	Stems, leaves and petals flaccid, petal abscission at 2 weeks.
Normal, medium humidity; stems in water	31	8	2	Leaves flaccid and slightly yellow; quality and petal retention fair after 8 weeks.
	40	4	1	Petal abscission initiated 1 day after hardening; stems and leaves turgid.
	50	2	0	Petals discolored and partly deteriorated at 2 weeks.

*Shelf-life for tulips stored for the period shown in previous column.

gen at a temperature of 31 F. Storage in the open at 31° F. with the stems in water was equally good, even though the water occasionally was frozen at the surface of the receptacle. Flowers stored for 8 weeks in either manner held satisfactorily for 2 additional days at 72° F. These were the only flowers free of petal abscission and mold development after 8 weeks of storage. Curvature of the stems was less severe for the flowers undergoing these treatments than for the others (Fig. 1).

The maximum holding period for all other conditions of storage was 2 weeks. Flowers held at 31° F. for 2 weeks in dry storage in humid air of normal composition were of fair quality, but inferior to those held in the open in water or without water in an atmosphere of 11 percent CO_2 and 10 percent O_2.

Fig. 1. William Copland tulips stored for 6 weeks at 31° F.: (A) In the open with stems in water; (B) in humid air without water; (C) in 11 percent carbon dioxide and 10 percent oxygen without water; and (D) in 16 percent carbon dioxide and 5 percent oxygen without water. The blooms of A and C are fairly tight and fresh; those of B are desiccated. Note the geotropic bending of the stems of D.

Flowers stored at temperatures above 31° F. were desiccated either upon removal from storage or shortly after placement at 72° F. A geotropic curvature of the stems was evident in storage first at 50°, later at 40°, and finally at 31° F. as the storage period was lengthened. A storage atmosphere of 16 percent carbon dioxide and 5 percent oxygen damaged the flowers in 2 to 4 weeks, whereas atmospheres of 19 and 21 percent carbon dioxide with 2 percent oxygen damaged the flowers within 2 weeks.

The cut flowers weighed 150 to 250 grams per dozen at harvest. Weight losses during storage were greatest at 50° F., with all samples showing a loss of at least 5 percent at the end of 4 weeks. The losses at 40° were less rapid than at 50°, and still slower at 32° F. The best storage treatment (without water in 11 percent carbon dioxide with 10 percent oxygen at 31°, and with water in normal air at 31° F.) resulted in minimum losses which did not exceed 2.5 percent of the original fresh weight of the tulips. The greatest weight losses at each of the three temperatures occurred in high carbon dioxide treatments.

Increases in the length of the stems and flowers were negligible at 31 and 40° F. An elongation of an inch or more occurred in some lots held at 50° F.

The color of the petals of most flowers at the time of placement in storage was "magenta rose" (027/1). A few blossoms were of a color matching "lilac purple" (031/2) on the color charts. Examina-

tion of the petal color at the conclusion of storage showed a general change from red or pink to a clear purple that was often accompanied by fading. Flowers stored in the open at 31° F. with the stems in water changed from "magenta rose" to "lilac purple" during the initial 3 days of storage and then remained constant for the remainder of the storage period up to 8 weeks.

Flowers stored without water showed a slight reversal of the trend and reddened when they were first placed into water upon removal from storage. Subsequent holding at 72° F., however, resulted in a loss of red color and an increase in purple. Flowers that had been stored for 8 weeks at 31° F. were "petunia purple" (032/) and became "imperial purple" (033/) after holding for 4 days at 72° F. under fluorescent light.

DISCUSSION AND CONCLUSIONS

The storage of cut flowers of tulips in closed containers without water was successful for periods in excess of 2 weeks only at 31° F. in an atmosphere of 11 percent carbon dioxide and 10 percent oxygen. This atmosphere inhibited the development of decay organisms without causing physiological injury to the flowers. In the other atmospheres studied, the flowers became unsuitable for marketing because of curvature of the stems and loss of turgor in the leaves and petals.

These injuries were similar to those noted by van Stuivenberg (1946, 1949) for tulips stored in carbon dioxide concentrations of 5 and 10 percent. Apparently, injury is affected by temperature as well as carbon dioxide, since his flowers were stored at 34° F. and in the studies reported here, flowers stored longer than 2 weeks in 11 percent carbon dioxide and 10 percent oxygen at 40° F. were injured. The oxygen level may also influence injury but, unfortunately, the oxygen contents employed by van Stuivenberg are not given.

Although differential responses of varieties to various oxygen and carbon dioxide levels are likely, the variety found to be best suited for storage by van Stuivenberg was Copland, probably the William Copland variety used here.

These tests re-affirm the findings of Whiteman et al. (1934) that cut flowers of tulip can be satisfactorily stored in the open with the stems in water at low temperatures. The uptake of water through the stems was adequate to offset water losses by transpiration under humidity conditions unfavorable for mold development.

This method of storage eliminates the hazards of gas injury in sealed containers. Other than the greater space requirements for storage in open containers, dry storage seemed to have no particular advantage over storage in water at 31° F. Closed packages, however, would be advantageous for long-distance shipment of flowers under refrigeration.

SUMMARY

Field-grown tulip blooms of the variety William Copland were stored at 31°, 40° and 50° F. in closed containers in which the atmospheres surrounding the tulips were adjusted to several levels of carbon dioxide and oxygen. The tulips were stored in a humid atmosphere, but without the stems in water. The flowers were stored for 2, 4, 6, and 8 weeks and then held in water at room temperature (72° F.) for observation of shelf-life. These were compared to flowers held dry in normal, humid atmospheres and to flowers stored with stems in water in the open for the same periods of time at the same temperatures.

Flowers were successfully stored for 8 weeks at 31° F., either with the stems in water in the open or without free water in an atmosphere of 11 percent carbon dioxide and 10 percent oxygen. Dry storage in humid air of normal concentrations of carbon dioxide and oxygen was unsatisfactory after 2 weeks because of decay development. Carbon dioxide concentrations of 16 percent caused injury to the tulips after 2 weeks of storage, and higher concentrations injured the flowers within 2 weeks. Temperatures above 31° F. were unsuitable for storage exceeding 2 weeks duration.

LITERATURE CITED

British Colour Council (1941). Horticultural Colour Charts II. British Colour Council. London.

Fischer, C. W. (1950). Long term cut flower storage, now possible. N. Y. State Flower Growers Bul. 62:6-8.

Mastalerz, J. W. (1953). Packaging flowers for holding at low temperature. N. Y. State Flower Growers Bul. 90:3.

_____ (1953). Conditioning flowers after holding at 32° F. N. Y. State Flower Growers Bul. 94:2.

Post, K. and C. W. Fischer (1952). Commercial storage of cut flowers. Cornell Ext. Bul. 853.

Van Stuivenberg, J. H. M. (1946). Gebruik van afwijkend gasmilieu bij vervoer en opslag van snijbloemen. (The use of gas mixtures in the transport and storage of cut flowers.) Tuinbouw 1946; No. 6:5-8.

_____ (1949). De mogelijkheid van verlenging van de levensduur van snijbloemen speciaal met het oog op het vervoen over grote afstand. (The possibilities of increasing the durability of cut flowers under long distance shipment.) Mededelingen Dir. van de Tuinbouw 12:717-734.

von Oppenfeld, Horst; R. S. Lindstrom, D. H. Dewey and J. W. Goff (1955). Cold storage of field-grown cut tulips. Mich. Agr. Expt. Sta. Quart. Bul. 38:273-278.

Whiteman, T. M.; R. C. Wright and D. Griffiths. (1934). The storage of tulip blooms. Florist's Exchange 82(3):11, 14.

COLD EXPOSURE OF TOMATO SEEDLINGS FOR EARLY FRUIT PRODUCTION

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MORE RESEARCH has probably been conducted on the tomato than any other horticultural plant. The control of fruiting and vegetative responses has been extensively studied. Yet it is strange that there has been so little work on factors that influence flower formation. This is all the more remarkable since tomato plant production in the northern states permits a high degree of control over the growing environment during the early seedling stages.

According to Went[1], the size of the tomato flower cluster varied with the night temperature. When nights were warm, flowers were fewer and smaller. Some growers have observed that the performance of tomato plants grown outdoors, or seeded directly in the field, often excels that of plants started in a warm greenhouse.

The size of the first flower cluster, the number of buds that develop into flowers, and the number of flowers which will set fruit in the first cluster are important factors in greenhouse and early outdoor tomato production. The height of the plant at which the first flower cluster appears is of considerable consequence. This is best determined by the number of leaves or nodes which precede the first cluster. If the flower cluster occurs after five to seven leaves rather than the usual eight to ten, early fruit production is favored and a normal pattern of flowering and fruiting follows.

Flower buds are formed in the seedling tomato plant 4 to 6 weeks before the first flowers open. This occurs in the 2- to 3-week interval immediately following the expansion of the seed leaves (cotyledons) and as the first true (plumule) leaves emerge. Exposure of seedlings during this 2-to 3-week period to low (50 to 55° F.) night tempera-

[1]Went, F. W. (1945). Plant growth under controlled conditions. V. The relation between age, light, variety and thermoperiodicity of tomatoes. Amer. Jour. Botany 32: 469-479.

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tures favors the production of more flowers in the first cluster. Also, fewer leaves are produced before the cluster.[2]

Low temperatures have usually been avoided in growing tomato seedlings. The standard practice has been to maintain night temperatures of about 65° F. The merits of a brief (2- to 3-week) cold exposure following cotyledon expansion have now been demonstrated for outdoor as well as greenhouse varieties.

EXPERIMENTAL PROCEDURE

During the past 2 years, several crops of tomatoes have been grown for yield performance in the greenhouse. In other studies, plants of several representative tomato types were subjected to various temperatures and held only until the effects could be observed on flowering of the first two clusters.

An additional test has been completed. Ten early tomato varieties were started in the greenhouse in March and transplanted outdoors the latter part of May. In each instance, representative seedlings were exposed during the sensitive period (the 2 to 3 weeks following expansion of the cotyledons) to night temperatures ranging from 50 to 55 and 65 to 70° F. (Fig. 1). Prior to and after the cold sensitive period, night temperatures approximating 65° F. were maintained. The results have been striking and reasonably independent of variety, type and season.

In Table 1, the number of leaves preceding the first flower cluster for four greenhouse varieties are listed for a typical crop seeded in January. Approximately seven leaves preceded the first flower clusters as the result of the 50 to 55° F. exposure, compared to nine for those grown at 65 to 70° F. Plants exposed for 2 to 3 weeks to 50 to 55° F. and then returned to 65° F. flowered as early as those grown continuously at 65 to 70° F. (fewer leaves preceded the first flower clusters as a result of the "cold treatment").

This may partially explain the behavior of direct-seeded field tomatoes that often flower and fruit as early as those grown from transplants started in warm greenhouses or hotbeds. General growth was also superior with the cold-exposed plants. The leaves were closer together (internodes were shorter), sideshoots were stronger, and the stems thicker.

[2]See Lewis, D. (1953). Some factors affecting flower production in the tomato. Jour. Hort. Sci. 28: 207-219; Verkerk, K. (1955). Temperature, light and the tomato. Dissertation, Hort. Laboratory, Agr. University, Wageningen, Netherlands. 226 pp.; and Wittwer, S. H., and F. G. Teubner (1956). Cold exposure of tomato seedlings and flower formation. Proc. Amer. Soc. Hort. Sci. (in press).

Fig. 1. Growth stages of tomato seedlings as related to the effects of "cold treatment" and flower formation. Left, a plant with the seed leaves (cotyledons) fully expanded and the first true (plumule) leaves beginning to emerge. The "cold treatment" should begin when plants have reached this size. Center, a plant 2½ weeks later after exposure to 50 to 55° F. Right, a plant after 2½ weeks at 65 to 70° F. night temperatures.

Equally as important as the number of leaves that preceded the first cluster were the numbers of flowers that occurred in the first cluster (Table 1). Low temperatures during the sensitive period increased flower number in all four varieties. The number of fruit set

TABLE 1—Effects of "cold treatment" of tomato seedlings on flowering of four greenhouse varieties

Variety	Leaves preceding first flower cluster		Flowers in first cluster	
	50-55°F.	65-70°F.	50-55°F.	65-70°F.
Spartan Hybrid	6.6	8.8	9.4	6.4
Michigan State Forcing	7.8	9.8	8.8	7.2
Michigan-Ohio Hybrid	6.8	8.0	9.0	6.0
Ohio WR3 Globe	5.8	8.6	7.2	5.4
Mean	6.8*	8.8	8.6*	6.3

*Differences in leaf and flower numbers from "cold treatment" highly significant (P = 0.01).

paralleled the number of flowers formed. This resulted in higher early yields. Total marketable yields and average fruit size were not affected.

It has been established[3] that the effectiveness of the "cold treatment" is a function of total cold received either day or night. During warm spring weather when plants are grown for transplanting outdoors, cool night temperatures of 50 to 55° F. were sufficient to induce earlier first clusters with greater numbers of flowers. It was further observed that prolonged low temperatures during seedling growth increased flower numbers in the second and third clusters.

A remarkable performance of tomato plants exposed to cold during the early seedling stages has been noted for early outdoor market types. Seeds of 10 varieties (Table 2) were planted March 25, 1955. After the seed leaves (cotyledons) had unfolded, plants of all varieties were simultaneously grown at warm (65 to 70° F.) night temperatures in the greenhouse and at cool (45 to 60° F.) night temperatures in a coldframe.

TABLE 2—Early yields of tomatoes from greenhouse (65°F. night temperature) and coldframe (45-60° F. night temperature) grown plants (cumulative yields to August 8—East Lansing, 1955)

Variety	Early yields (pounds per plant)		Percent increase from coldframe grown plants
	Greenhouse	Coldframe	
Siouxann	4.5	10.5	133
Early Hycross	6.6	9.8	49
Hybrid A	4.5	8.3	84
Moreton Hybrid	5.5	7.9	44
Fireball	3.7	7.8	111
Big Early Hybrid	3.9	6.6	70
Valiant	4.6	6.5	41
Foremost E-21	3.3	5.5	67
Early Chatham	3.8	4.8	27
Cavalier	2.5	3.4	36
Mean	4.3	7.1*	65

*Increased early yields of coldframe-grown plants highly significant (P = 0.01).

As with greenhouse-adapted varieties, the plants exposed to cold in the seedling stages produced more flowers on the first clusters, flowered after fewer numbers of leaves, and had shorter internodes, heavier stems and stronger sideshoots (Fig. 2). While it is recognized that a lower temperature was not the only modification imposed on

[3]Wittwer and Teubner. Op. cit.

Fig. 2. Differences in growth and flowering between coldframe (left) and greenhouse (right) grown tomato plants. The "cold-exposed" plants (left) flowered after fewer numbers of leaves; produced more flowers in the first clusters; and had shorter internodes, heavier stems, and stronger sideshoots (variety, Valiant).

the coldframe-grown plants compared to those grown in the greenhouse, it is believed that this was the most important difference between the two environments.

Early yields in pounds per plant, cumulative to August 8, are recorded in Table 2. Coldframe-grown plants yielded an average of 65 percent more for the first 3 to 4 weeks of picking. The increase in early yield for Fireball, Siouxann and Hybrid A was greater than for Cavalier or Early Chatham, as a result of the low temperature treatment ($P = 0.05$ for variety x temperature). Valiant, Early Hycross, Moreton Hybrid, Big Early Hybrid and Foremost E-21 were intermediate.

Mean weekly yield increments in pounds per plant for all 10 varieties resulting from the two temperature treatments are illustrated in Fig. 3. It is apparent that the greatest increases in early yield from the "cold treatment" were during the third and fourth weeks of harvest. For the first week, yields from greenhouse-grown plants were slightly higher than those grown in the coldframe. This resulted from a slower growth at the prolonged cooler temperatures. Thus, earlier

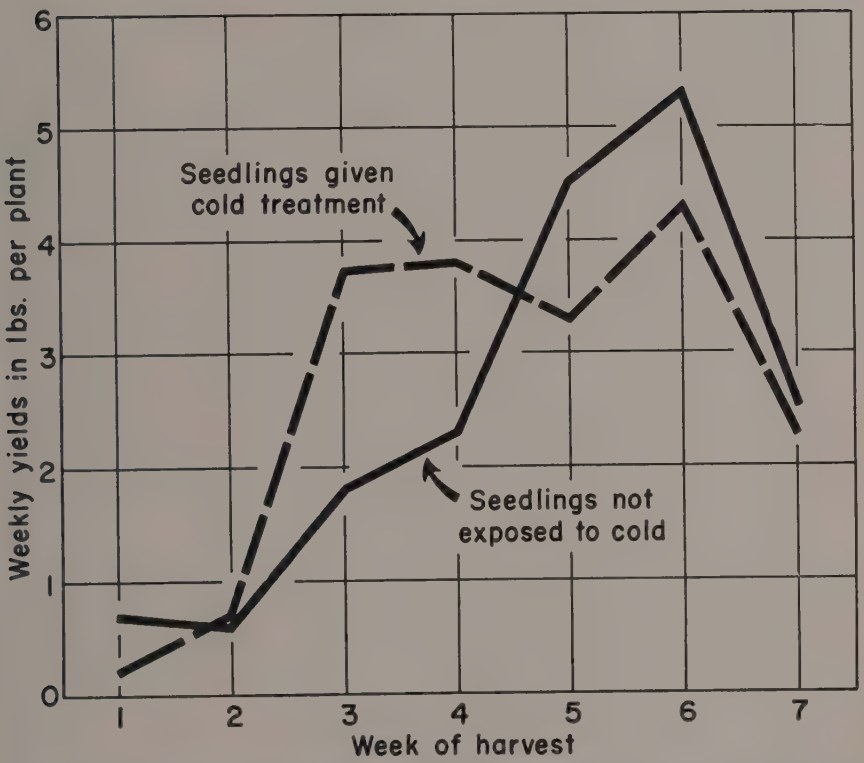

Fig. 3. Weekly yield increments of marketable fruit harvested from seedlings given the "cold treatment" (coldframe-grown) and from seedlings not exposed to cold (greenhouse-grown) plants. Mean values in pounds per plant for 10 tomato varieties—summer, 1955.

seeding for tomatoes given the "cold treatment" is suggested. Total marketable yields of the coldframe-grown plants (18.3 pounds per plant) and those grown in the greenhouse (17.8 pounds per plant), as well as fruit size, did not differ significantly. However, a more constant weekly production by the coldframe-grown plants occurred after the third week.

CONCLUSIONS AND RECOMMENDATIONS

The importance of low (50 to 55° F.) night temperatures for earlier and increased flower formation in the tomato plant is demonstrated; the sensitive period being the 2- to 3-week interval following cotyledon expansion of the seedlings. This brief period of low temperature

induces more flowers to develop in the first cluster, with fewer leaves preceding their appearance. The favorable effect on flowering is later reflected in higher early yields of fruit. Recommendations for the "cold treatment" of tomato seedlings are as follows:

(1) Germinate seed in the usual manner at 70 to 75° F., and hold the seedlings at warm temperatures until the seed leaves are fully expanded and the first true leaf is just beginning to show. This is usually about 2 weeks from the seeding date, and allows time for transplanting from the seedling flats.

(2) When the first true leaf begins to show (either before or after transplanting), grow the young plants for 2 to 3 weeks at a night temperature of 50 to 55° F. Either lower the temperature in the plant house or transfer the plants to a cooler area. Expose to as much sunlight as possible.

(3) After 2 to 3 weeks of cold, raise the night temperature and maintain it at 60 to 65° F. thereafter.

(4) If tomato seedlings are to be given the "cold treatment," they should be seeded 7 to 10 days earlier than normal to compensate for the reduced rate of growth during the 2 to 3 weeks of cold. Sterilized soil should also be used to avoid loss of plants from "damping-off".

(5) The "cold treatment" increases the numbers of early flowers, but it does not affect early fruit set. Therefore, the use of a fruit-setting "hormone" spray when night temperatures fall below 59° F. may be necessary to attain the maximum benefits of the "cold treatment".

(6) Higher early yields from cold-treated plants can be obtained only if there is an adequate supply of moisture and fertilizer available for the growth of an increased number of fruit.

THE THREE-TEAM METHOD OF PICKING APPLES[1]

By J. H. LEVIN[2] and H. P. GASTON[3]

PICKING IS THE ONLY step in the growing, handling and packing of apples that has not been extensively mechanized. It is difficult, time-consuming labor, and growers everywhere are interested in the development of techniques and machines that will make harvesting easier, faster and less costly.

The study reported here was undertaken to develop picking methods and equipment that would increase the efficiency of the harvesting operation.

HOW THE STUDY WAS CONDUCTED

Time and motion studies of apple-picking reported in 1953[4] led to the conclusion that the efficiency of the harvesting operation could be increased. During the 1954 season, the "Three-Team Method" of harvesting apples was developed and tried on a commercial harvesting operation including 2,360 bushels of apples.

The system was tested again in 1955, utilizing several commercially available and two experimental picking aides. In that year 5,190 bushels of fruit were included in the trials.

All of the experimental picking was done by a group of 12 men. During the first day this crew (divided into four teams) worked in the conventional manner; i.e., they used picking buckets and 22-foot ladders. Each group removed all the fruit from one tree before proceeding to the next. The average picking rate for this day was 9.4 bushels per man per hour. In evaluating the methods and equipment used later, the results were compared with those obtained during this first day when the basic rate was established.

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[1]Based on work carried out jointly by the Mechanical Preparation and Conditioning Section of Agricultural Engineering Research Branch, A.R.S., U.S. Department of Agriculture; and Departments of Horticulture and Agricultural Engineering, Michigan State University, East Lansing.

[2]Agricultural engineer, Agricultural Engineering Research Branch, A.R.S., U.S. Department of Agriculture.

[3]Department of Horticulture, Michigan State University.

[4]Gaston, H. P., and J. H. Levin (1953). Time and motion studies of apple picking made to determine the possibilities of mechanizing harvest operations. Mich. Agr. Exp. Sta. Quart. Bul. 36: 18-23.

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Fig. 1. The ground crew moves in and picks all the apples that can be reached from the ground (usually about 35 percent of the fruit on the tree). Since they do not carry ladders and can move about freely, they pick rapidly.

THE THREE-TEAM METHOD

In this method of picking, a "ground crew" consisting of three or four workers begins by picking all of the apples that can be reached from the ground (Fig. 1). The fruit is harvested in picking buckets and then transferred to field crates as in the conventional method. The members of this crew do not carry ladders. As soon as one tree has been finished, they move to the next one in the row and proceed as before.

The ground crew is followed by a "midsection crew" of three or four pickers who work from 7-foot stepladders, or other equipment which enables them to pick the fruit that remains in the tree below a height of approximately 14 feet (Fig. 2).

These workers are followed by a "top crew" consisting of three or four pickers using ladders of sufficient length, or other equipment that will enable them to reach all of the fruit that remains on the tree (Fig. 3).

The number of workers in the various crews should be regulated in such a way that they move through the orchard at about the same rate. For example, in an orchard where none of the fruit is more than

16 feet from the ground, one or two men could probably handle all that was left by the "midsection crew."

EQUIPMENT

Used by the ground crew: The conventional picking bucket is the only piece of equipment used by those who work from the ground.

Used by the midsection crew: In addition to picking buckets, these workers must be supplied with equipment which will enable them to reach the fruit in the midsection of the tree. A 7-foot stepladder serves this purpose and is available on most fruit farms.

In an effort to increase the efficiency of the midsection crew, various other pieces of equipment were tried. A lightweight picking platform that could be moved by the individual picker was developed. The experimental platform was 4 feet wide, 8 feet long and 6 feet in height. It had two wheels[5] at one end and a handle at the other to facilitate moving (Fig. 4). Such a platform can be constructed at a cost

[5]Wheels 18 inches or more in diameter proved more effective than smaller ones.

Fig. 2. The midsection crew follows the ground crew through the orchard. They use 7-foot stepladders or other equipment that enables them to reach the fruit in the tree up to a height of approximately 14 feet.

Fig. 3. The top-section crew uses long straight ladders or other equipment that enables them to reach the fruit in the top of the tree.

of $15 or $20 for materials. Incidentally, this piece of equipment might prove useful as a pruning as well as a picking aid.

The worker moved the platform to a position under the tree from which a considerable amount of fruit could be reached. He placed a sufficient number of crates on the platform to hold the fruit to be picked at this "set." He then climbed to the platform by means of a built-in ladder, picked the fruit and placed it in the crates. When all of the fruit that could be reached had been picked, he climbed down, lifted the filled crates to the ground and moved the platform to the next set and proceeded as before. As soon as one tree was finished, the platform was rolled to the next tree and the operation repeated.

Another type of platform was built on a Speed-sprayer (Fig. 5). Using this piece of equipment as a "chassis" reduces the cost of the platform. If necessary, water could be put into the sprayer tank to increase stability. The platform was 8 feet wide, 16 feet long and 6 feet above ground. It could be detached from the sprayer in a matter of 20 to 30 minutes. The materials cost of this aid was approximately

Fig. 4. A lightweight manual platform can be used to advantage in picking the midsection. Once the platform is in position, the picker can move about freely in an area 8′ x 4′. Several bushels of fruit can usually be reached from one set.

$75. Adding the labor cost brought the total outlay up to approximately $200.

In the trials, several pallets and from 20 to 30 crates were placed on the platform by means of a lift truck. It was then pulled into position under a tree, and the driver and one or two other pickers climbed onto the platform and began picking. When all of the fruit that could be reached from the first set had been picked, the platform was moved successively to other sets on the same side of the row.

When all of the fruit that could be reached from one side of the row of trees had been picked, the platform was turned around and used in picking the other side of the same row. When the crates had

been filled, the platform was pulled to the loading dock where the filled crates were unloaded and replaced with empties; it was then moved back to the orchard.

Several interested growers have constructed mechanical aids to assist them in picking the midsection. One such device was a wooden platform built on a tractor-mounted hayloader, which could be lifted into the tree by hydraulic cylinders. Another aid was a power-operated step-platform. Other platforms of various types were also tried.

Used by top-section crew: These workers must be supplied with picking buckets and equipment which will enable them to reach the fruit in the tops of the trees. Straight ladders of sufficient length serve this purpose and are found on most Michigan fruit farms.

Attempts have been made to develop machines that will hold a worker in picking position in the upper part of a tree. These machines usually consist of either hydraulically operated booms or hoists that can be controlled from the picking platform. The authors tried all of the machines of this type available in Michigan.

Fig. 5. This experimental combination platform and orchard trailer enables the workers to rapidly pick the apples which they can reach. It is, however, impossible to reach all of the apples borne in the midsection; and considerable time is lost when the platform is being used as a trailer to move the fruit out of the orchard.

TABLE 1—Comparison of the average rates (bushels per man per hour) at which apples were picked by crews using the conventional system and the three-team method

Crew	Equipment used					
	Picking bucket only	Picking bucket and 7-ft. step-ladder	Picking bucket and manual platform	Picking bucket and sprayer-mounted platform	Picking bucket and 22-ft. ladder	Picking bucket and hydraulic hoist
Conventional.....					9.4	
Ground.....	12.8					
Midsection.....		9.8	11.2	11.4		
Top.....					7.0	11.5

RESULTS

Table 1 summarizes the data obtained when different sections of the tree were picked by the three-team system.

Picking the lower section. The ground crew picked at the average per-worker rate of 12.8 bushels per hour (Table 1). This was 3.4 bushels more than the average rate attained by the same pickers working the entire tree in the conventional manner. The relatively high rate is probably due to the fact that the men were free to use both hands; they did not carry ladders, and worked from the ground where their footing was secure.

Picking the midsection. When picking the midsection, workers using 7-foot stepladders attained a rate of 9.8 bushels per man per hour. This was less than the rate achieved by the ground crew. The decrease was due to the fact that the work was done from ladders which must be carried, set up, ascended and descended frequently. The rate was, however, slightly higher than that attained when the conventional method was used.

When the midsection crew used the experimental manual platform, they picked at the rate of 11.2 bushels per man per hour. This rate compared favorably with that attained by the ground crew. The relatively high rate was probably due to the fact that, once the platform was in position, the picker could move about freely in an area

32 feet square, and several bushels of fruit could be reached from a given set.

When the sprayer-mounted platform was used in picking the midsection, the apples were harvested at an average rate of 11.4 bushels per man per hour. While the rate at which the fruit was picked was relatively high, only about 30 percent of the apples in the midsection could be reached when the platform moved up one side of the row and down the other.

The platform was also used to move the fruit to the loading dock. This meant that the device was in picking position for only 70 percent of the time. Considering all these factors, the sprayer-mounted platform was less satisfactory than stepladders.

Picking the top section. When workers used 22-foot ladders in picking the tops, the rate of picking was 7 bushels per man per hour. This was 5.8 bushels less than the rate at which the ground crew operated; 2.8 less than that of the midsection crew; and 2.4 less than the rate attained by workers picking in the conventional manner. This relatively low rate was due to the fact that these top pickers carried long ladders which are heavy and difficult to set. They also spent considerable time in ascending and descending. In addition, the footing is less secure and it is often necessary to hold onto the ladder with one hand while picking with the other.

If a practical method can be found for increasing the rate at which the tops can be picked, the overall efficiency of the harvesting operation will be materially improved. Further research should be directed at the problem of increasing the efficiency of the top crew.

The commercial booms and hoists which were tried enabled the workers to pick the tops at the rate of 11.5 bushels per man per hour. This was considerably better than when 22-foot ladders were used, and approached the rate achieved by the ground crew. These machines are expensive, however, and at present prices the advantage of the increased rate at which apples are picked is more than offset by overhead and maintenance costs of the machines.

Results Obtained When Different Combinations of Equipment Were Used. Table 2 shows the rate, the per-bushel cost, the equipment cost and total per-bushel cost of picking apples when various combinations of equipment were used. In all cases the ground crew operated in the same way.

TABLE 2—Average rates at which apples were picked and estimated average costs incurred when various combinations of equipment were used

Crew	Equipment used	Bushels per man per hour	Labor cost* per bushel	Estimated equipment cost† per bushel	Total estimated cost per bushel
Conventional	Picking bucket and 22-ft. ladder	9.4	20c	.2c	20.2c
Ground	Picking bucket	10.1	18.6c	.4c	19.0c
Midsection	7-ft. stepladder				
Top	22-ft. ladder				
Ground	Picking bucket	10.4	18.1c	.5c	18.6c
Midsection	Manual platform				
Top	22-ft. ladder				
Ground	Picking bucket	8.4	24.4c	.5c	24.9c
Midsection	Spray-rig platform				
Top	22-ft. ladder				
Ground	Picking bucket	10.7	17.6c	10.0c	27.6c
Midsection	7-ft. stepladder				
Top	Hydraulic hoist				

*Labor figured at $1.88 per hour. This rate was used because it was the amount earned by the average worker when the crew picked in the conventional manner and was paid piecework rates of 20 cents per bushel
†Figures include interest, maintenance and depreciation.

The greatest number of bushels per hour (10.7 per man) was picked when the middle crew worked from 7-foot stepladders and the top crew used mechanical booms. However, the high cost of the booms resulted in the highest per-bushel cost (27.6 cents) of any of the methods tried.

The per-bushel rate attained when the sprayer platform and a 22-foot ladder were used was less than the conventional rate, and the per-bushel cost was more.

When 7-foot stepladders and 22-foot straight ladders were used, the results were slightly superior to those attained when the conventional method was used.

The cost per bushel was lowest (18.1 cents) and the rate of picking was highest when the stepladder was replaced by the manual platform.

ADVANTAGES

The three-team system makes it possible to increase the average rate at which apples can be picked. Although the increase is relatively small (1 bushel per worker per hour when the most practical combination of equipment is used), even a small gain is significant when the number of units to be harvested is great.

The system also makes it possible to lower the total per-bushel cost of picking. Under the best combination of equipment, this reduction was 1.4 cents per bushel.

The use of the three-team system makes is possible to use to good advantage specialized equipment for picking the tops of trees. The use of existing mechanical hoists increased the rate of picking from 9.4 to 10.7 bushels per man per hour. If machines could be developed that were both effective and inexpensive, the cost of picking could be materially reduced.

Although they may not be able to use ladders to advantage, inexperienced pickers, women and teenage boys can, if they are willing, pick from the ground with reasonable effectiveness. When the three-team system is used, workers of this type can often be used to advantage in the ground crew.

In the three-team method, all the fruit in the lower and midsection is picked before ladders or other equipment are used in the tops. Less fruit is bruised and knocked off the tree than with the conventional method.

One of the growers in whose orchard the three-team system was tried stated his intention of using a modified version of the method in 1956. He plans to send his entire picking crew through a given "block" of trees and have them pick all the fruit they can reach from the ground. The crew will then be provided with stepladders and will go over the trees again and pick all the fruit that can be reached from these aids. When this work is completed, they will be given long ladders with which to pick the tops. If good results are to be obtained, the team will have to be made up entirely of men who have the strength and ability to use the ladders effectively.

The system proposed above would simplify accounting and make it easy to keep the fruit from the three sections separate. This might make grading easier and more effective.

LIMITATIONS

Pickers who have become accustomed to the conventional method may be reluctant to try a new system which would mean working in a somewhat different way.

When the conventional method is used, not more than three or four workers pick to advantage in any one tree. In the three-team method, however, 10 to 12 pickers work, at various times, on a single tree. It is therefore more difficult to keep an accurate account of the number of bushels picked by the individual worker.

If the pickers who make up the crew are to receive approximately the same amount of compensation for a day's work as they would receive were they working in the conventional manner, the ground crew must be paid less and the top crew more than the conventional piecework rate. This means that three different rates must be used in calculating wages.

If, while being paid by the hour, the various crews involved would maintain the same picking rate as they maintain on piecework, most of the accounting difficulties would be eliminated. However, most growers say that pickers slow down when paid by the hour.

CONCLUSIONS

★When the most effective equipment is used, the three-team method increases the average rate at which apples are picked and lowers the per-bushel cost of harvesting.

★The increased rate at which apples are picked is due to the fact that each team does a specialized job and uses equipment that is suited to the work.

★While the method has advantages, it increases accounting difficulties when piecework rates are paid.

★The system has enough merit to warrant trial by interested growers.

★The development of inexpensive aids which would make it easier to pick the fruit in the tops of the trees would probably lead to widespread use of the method.

WEIGHING CHERRIES THAT ARE TRANSPORTED IN WATER[1]

By H. P. GASTON[2] and J. H. LEVIN[3]

UNTIL RECENTLY, practically all the red tart cherries grown for processing were handled in lugs. Producers were paid on the basis of weights obtained while the fruit was in these containers.

During the last few years a method of handling cherries in water, rather than in lugs, has been developed.[4] When this system of handling is used, the fruit is put into water at the orchard or at receiving stations. Putting cherries in water at the orchard made it necessary to devise new methods of weighing the fruit.

Several systems were developed and used successfully by a few processors and growers during the 1955 season. Other producers and packers are interested in moving cherries directly from orchards to processing plants and will probably do so as soon as they become convinced that the weight of cherries that are transported in water can be determined quickly and accurately.

Four practical weighing techniques have been developed. One or more of these should prove satisfactory to all concerned. The purpose of this report is to make information on various methods of weighing cherries transported in water available to interested growers and processors.

OBTAINING WEIGHTS AT THE ORCHARD

The most direct method of obtaining the weight of cherries to be handled in water is to scale the fruit at the orchard, while it is still

[1]Based on work carried out jointly by the Mechanical Preparation and Conditioning Section of Agricultural Engineering Research Branch, A.R.S., U.S. Department of Agriculture; and Departments of Horticulture and Agricultural Engineering, Michigan State University, East Lansing. Special credit is due Floyd Cargill Orchards and R. C. Munger Orchards, Hart, Michigan. The Oceana Canning Company of Shelby, Michigan; Gleason and Company of Mapleton, Michigan; and Cherry Growers, Inc. of Traverse City, Michigan, contributed to the success of the project.

[2]Department of Horticulture, Michigan State University.

[3]Agricultural engineer, Agricultural Engineering Research Branch, A.R.S., U.S. Department of Agriculture.

[4]Levin, J. H., and H. P. Gaston (1956). Grower handling of red cherries. U.S. Dept. Agr. Circ. 981. In press.

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dry. There are two ways in which this can be done. Each method was used successfully during the 1955 harvest season in weighing several million pounds of fruit.

Weighing all the cherries. Cherries that are to be placed in water at the orchard are usually moved to the loading dock in the pails in which they are picked. The net weight of the fruit can be determined by weighing the filled pails (usually 15 or more at a time) and subtracting the weight of the containers (after they have been emptied and scaled back) and any cull fruit that is sorted out after the gross weight of the fruit has been determined. This work is usually performed by a "weigh-master" stationed at the loading dock.

Any accurate scale with a capacity of 500 pounds or more, that can be moved to the dock, should prove satisfactory. Such a scale can be purchased for approximately $150.00.

Calculating the weight on the basis of random samples. When this method is used, the weigh-master selects at random five or more pails from each trailer load of cherries that arrives at the dock. He then weighs these pails, subtracts the weight of the "empties" and divides by the number of containers involved. The result is the average weight of the fruit in a single pail. The total weight of the cherries in the load is determined by multiplying this figure by the number of pails in the lot.

Most orchard trailers have a capacity of approximately 100 pails. If all the pails are well filled[5] and a minimum of 5 percent of the fruit is included in the sample, the calculated weight of the load should be accurate to within one-half of 1 percent. This would mean that in a trailer load of fruit weighing 1,500 pounds, the error should not exceed 7½ pounds.

Weights of several trailer loads of cherries were calculated in this way, and the accuracy of the figures was checked by weighing all the fruit in the various lots. In no case did the error exceed the figure mentioned above. When a considerable number of loads are involved, the errors tend to "cancel out".

Accurate weights can be determined by either of the methods outlined above. When, however, the weighing is done at the orchard, it is necessary to station a capable weigh-master at each of the producing units involved. This worker must be acceptable to both grower and processor. In practice, the weigh-master is usually a competent but

[5]A check of 500 pails showed that well-filled units did not vary in weight more than a half pound.

disinterested party, such as a schoolteacher. In order to insure impartiality, the grower and processor usually contribute equal shares of the salary paid to the person doing this work.

Employing a weigh-master may not prove to be a serious disadvantage when only a few large orchards are concerned. Doing so, however, adds to the expense of handling, and the number of qualified workers available may be limited. Because of these facts, weighing at the orchard may prove impractical when the number of growers involved is large and/or the tonnage of cherries to be handled is relatively small.

OBTAINING WEIGHTS AT THE PROCESSING PLANT

The weight of cherries that arrive in water at the processing plant can be determined accurately at that point. At-the-plant weighing is usually more practical than at-the-orchard weighing when a considerable number of growers are involved.

Two methods are available. The one used will depend on circumstances and the personal preferences of those concerned. In both methods the wet drained cherries are weighed. The weight on which payment to the grower is based is then calculated by subtracting 1 percent of the weight of the wet, drained fruit from the total.

The weight of a typical load of water-transported cherries included in the trials was calculated as indicated below:

Weight of wet, drained cherries	2,996.00 pounds
1 percent of 2,996	29.96 pounds
Calculated weight of dry fruit	2,966.04 pounds

In practice, the fractional pounds (.04) were disregarded. An explanation of how the 1 percent factor was determined is presented later in this paper.

Weighing wet drained cherries after unloading. Although this system requires special equipment, it is simple, fast and accurate. Once the equipment is installed, it can be used for weighing cherries that arrive in lugs as well as for those that arrive in tank trucks.

In using this method, the fruit is flumed (or poured from lugs into a water-filled "boot", from which it is elevated, drained and moved over an automatic or semi-automatic belt or hopper scale which weighs the wet, drained cherries. From this total weight, the weight of the fruit can be determined by deducting 1 percent.

Scales of the type needed to do this work can be obtained from most scale manufacturers.

Weighing wet, drained cherries before unloading. When this method is used in determining the weight of cherries arriving in water, the first step is to drain off the "free water" in the tank truck. The tank should be allowed to drain 3 to 5 minutes after the water ceases to flow in a steady stream. The tank truck containing the wet, drained cherries is then weighed, the fruit flumed out, and the empty tank truck weighed back. The weight of the wet, drained cherries is then determined by subtracting the tare from the gross weight of the tank truck and cherries. The original or net weight of the fruit, without surface water, can be calculated by subtracting 1 percent.

Although accurate weights can be determined by this method, it may not prove entirely satisfactory. Draining the tanks before weighing takes time and may create water disposal traffic and problems. In addition, water must be added to the tank a second time in order to flume out the fruit.

Under unfavorable conditions, such as advanced maturity or high temperatures, the fruit may be damaged if allowed to stand in a deep tank without the cushioning effect of water. Operators should: 1) avoid tanks of excessive depth; 2) drain all loads for not less than 3 and not more than 5 minutes; 3) refill the tanks with water as soon as they have been weighed.

TABLE 1—Weight of water which adheres to cherries submerged in water for periods of from 10 minutes to 2 hours and then drained for 3 to 5 minutes

Original weight of dry fruit (pounds)	Trials (number)	Weight of water which clung to wet, drained cherries expressed as percent of total weight of wet, drained fruit.	
		Range (percent)	Average (percent)*
4	43	.91 to 1.34	1.22
1,000	7	.89 to 1.18	1.07
3,000	5	.81 to 1.07	.92

*The figures in this column appear to indicate that the amount of water which adhered to the cherries was affected by the number of pounds in the lot. The 4-pound lots were weighed early in the season when the cherries were relatively small. The 3,000-pound lots were weighed late in the season when the fruits were larger. This means that the weight differences were probably due to differences in fruit size rather than lot size. Using the 1 percent factor throughout an entire season would tend to average out differences or reduce them to a point at which they could be disregarded.

How the 1 percent factor was determined. Fifty-five lots of dry cherries varying in weight from 4 pounds to 3,000 pounds were weighed, allowed to stand in water for various periods of time, drained and reweighed. From these data, the weight of the water adhering to the cherries after they were drained was calculated. The results are summarized in Table 1.

The percentage of water which clung to the cherries varied from .81 to 1.34 percent of the total weight of the wet, drained fruit. The weighted average of all lots was almost exactly 1 percent.

The cherries included in the experimental lots were allowed to stand in water for periods varying in duration from 10 minutes to 2 hours. Within these limits, the length of "soak" had no apparent effect on the gain in weight.

Unpublished results of work done by C. L. Bedford, department of horticulture, Michigan State University, indicate that, under normal conditions, cherries do not gain weight when allowed to stand in water. Some processors are of the opinion that cherries allowed to "soak" for several hours do become slightly heavier.

Ordinarily, however, cherries that are moved directly from nearby orchards to processing plants are in transit for only relatively short periods of time. Cherries that are moved from receiving stations to more distant processing plants are usually weighed at the receiving station before being put into water.

It is believed that increases in weight due to absorption of water either do not occur or are of no practical significance.

Small cherries present more surface area than large fruit of the same total weight. Other things being equal, this probably means that the amount of water which clings to wet, drained cherries depends to some extent upon the size of the fruit.

Although no data are available, the differences in fruit size are not likely to be great, and differences in the weight of water which clings to the fruit would probably be so small that they could be safely disregarded. If a slight difference did exist, applying the 1 percent factor would tend to reward those growers who produced larger cherries and penalize those who grew small ones.

Although the amount of water which clings to wet, drained cherries is probably affected by several factors, it is believed that these factors have only minor effect on the weight.

Weighing cherries in filled lugs and scaling back "empties", or calculating weights on the basis of an assumed lug weight which may

be either heavier or lighter, undoubtedly causes errors when the conventional method of weighing is used.

Experience gained during the 1955 season indicates that weighing wet, drained cherries and then applying the 1 percent factor will enable processors to calculate the weight of cherries transported in water with as much accuracy as can be achieved by the in-the-lug method of weighing.

CONCLUSIONS

Several effective methods of weighing cherries transported in water have been developed.

The particular method selected by a given processor and the growers who supply him will depend upon circumstances and the personal preferences of those concerned.

MICHIGAN FARMERS' USE OF RADIO AND NEWSPAPER MARKET NEWS

By JOEL SMITH
DEPARTMENT OF SOCIOLOGY AND ANTHROPOLOGY

SINCE 1917, the United States Department of Agriculture has collected and reported news of daily prices and supplies of agricultural commodities at various large markets. Through the years, this service has been expanded to include a greater number of commodities and market locations. The department does not offer this news directly to the commercial farmer. Instead, the information is made available to newspapers and radio stations which may edit and process it before passing it on to the public. A large number of Michigan newspapers and radio stations transmit this news to the farmers of the state.

The market news program is maintained because reliable information about market prices is necessary for intelligent decisions about marketing and, perhaps, production. It may be of use in reaching decisions on such matters as the proper time and place to sell and the fairness of prices being offered. A farmer may even use his knowledge of prices in making decisions about the amounts and kinds of commodities to produce. A crucial aspect of the market news program is that it is organized to deliver comparable and reliable information to all farmers as rapidly as possible.

Although the service is intended to reach all farmers, it does not succeed in doing so. Moreover, not all of the farmers who are reached by the information use it in making decisions. Furthermore, many farmers experience various degrees of dissatisfaction with the material they receive and the means by which it is brought to them. This research project was designed to answer such questions about the market news program as:

1) How many Michigan farmers regularly use newspapers and radio as sources of market news?

2) What kinds of criticisms of this news do they have?

3) How may these variations in use be explained?

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It should be noted that the term "use" as it is discussed here refers only to regular exposure to the market information carried by Michigan's newspapers and radio stations. No effort has been made to determine the ways in which Michigan farmers apply this information. While application is certainly of crucial importance in evaluating the effectiveness of the market news program, exposure is a prior consideration since there can be no application of information that has not been obtained.[1]

The information discussed in this report comes from interviews with 193 Michigan farmers residing in eight different counties. The counties, and the townships within them, in which interviews were conducted were stratified and chosen on the basis of random sampling procedures. Stratification of counties and townships was designed so as to insure the inclusion of both heavily and lightly populated rural areas in the sample.

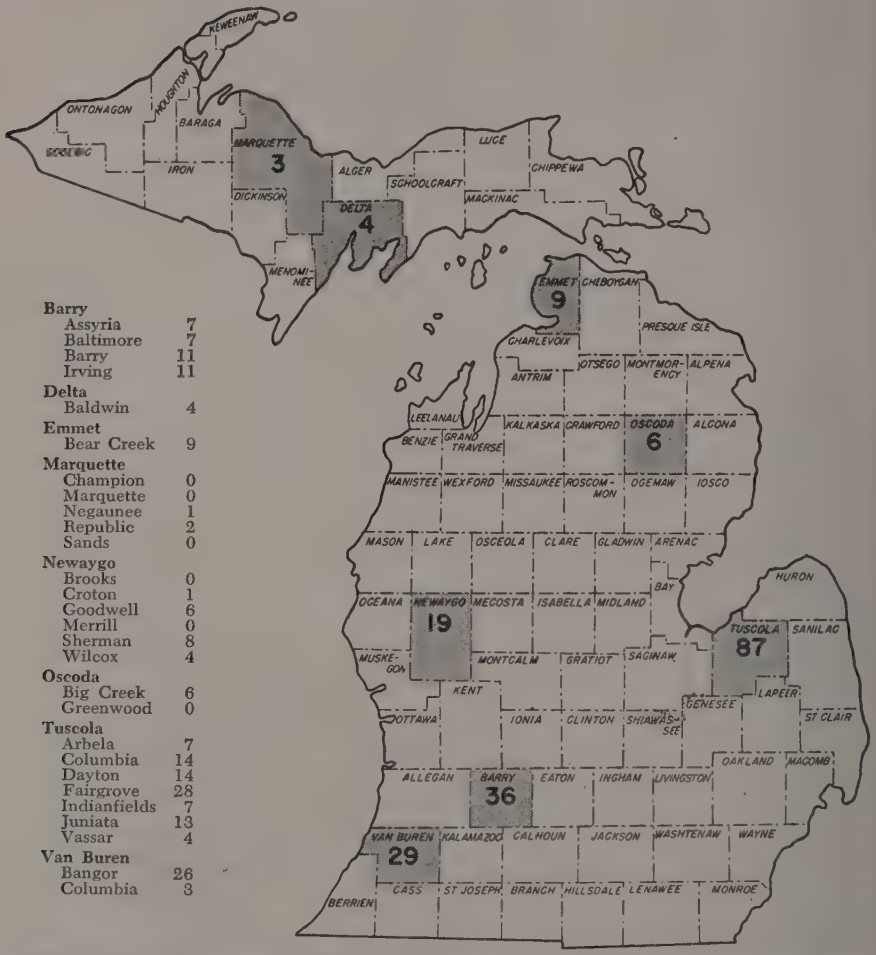
Sampling rates for areas were set in such a manner that the completion of interviews with all resident farmers who qualified would yield a 3.2 percent sample of the group selected for study. The counties in which interviews were conducted, as well as the townships selected for interviewing and the number of interviews actually obtained in each, are shown in Fig. 1.

The investigation was limited to farmers between the ages of 35 and 44 who had had at least some high school but no college education. Specific age and education limits were necessary because previous research findings demonstrated that the extent of regular use of all of the mass media of communication varies considerably with age and education.

In order to qualify for the sample, farmers in this age and education category had to have marketed farm products.[2] For this reason, the findings cannot be generalized to all Michigan farmers. However, because the sample members are younger and better educated than the bulk of the state's farmers, we may expect with some confidence that the estimates of non-use reported here are considerably lower than they would be for all of the state's farmers.

[1]The reader may be disturbed by the fact that the study is largely limited to an examination of factors related to market news exposure. The use to which such news is put may be equally or more important. However, this problem was not investigated because the problem of exposure seemed to have logical priority. Members of the department are currently engaged in an extensive evaluation of the uses of market news.

[2]A comprehensive description of the design of this study may be found in Smith, Joel (1954). Organization of the farm and mass communication. Dissertation for degree of Ph.D., Northwestern University, Evanston. (Unpublished). Chapter 2.



Barry	
Assyria	7
Baltimore	7
Barry	11
Irving	11
Delta	
Baldwin	4
Emmet	
Bear Creek	9
Marquette	
Champion	0
Marquette	0
Negaunee	1
Republic	2
Sands	0
Newaygo	
Brooks	0
Croton	1
Goodwell	6
Merrill	0
Sherman	8
Wilcox	4
Oscoda	
Big Creek	6
Greenwood	0
Tuscola	
Arbela	7
Columbia	14
Dayton	14
Fairgrove	28
Indianfields	7
Juniata	13
Vassar	4
Van Buren	
Bangor	26
Columbia	3

Fig. 1. Location and distribution of sample areas and sample members interviewed.

EXTENT OF USE OF NEWSPAPER AND RADIO MARKET NEWS

When asked whether or not they regularly read the market news reports carried in newspapers, 46 (24 percent) of the 193 farmers reported that they did not do so. However, since only 166 (or 86 percent) of the members of the sample read a daily newspaper regularly, this meant that 89 percent of the farmers who read newspapers regularly read the market news in those papers.

There is a tendency for farmers to read market news in only one newspaper, whether they read more than one paper regularly or not

TABLE 1—Extent of newspaper reading and market news reading

Newspapers read regularly	Newspapers read for market news			
	None	One	Two	Total
None.....	27	...	...	27
One.....	16	121	...	137
Two.....	3	12	11	26
Three.....	...	1	1	2
Four.....	...	...	1	1
Total.....	46	134	13	193

(see Table 1). While market news is read in 89 percent of the newspapers read by farmers who regularly read only one daily newspaper, only 63 percent of the papers read by farmers reading two or more papers regularly are used in this way. Obviously, newspaper reading for a farmer does not necessarily mean market news reading.

Only four of the farmers interviewed did not consider themselves to be regular listeners to the radio. Thus, 98 percent of the members of the sample were regular radio listeners. Of these, 36 did not listen regularly to a program providing market news. Therefore, 81 percent of the farmers who listened to the radio regularly, and 79 percent of the sample members, were regular listeners to market news programs.

A comparison of regular newspaper readers who read market news (89 percent) with regular radio listeners who listen to market news broadcasts (81 percent) shows that significantly more of the newspaper readers include market news in their reading than radio listeners include market news broadcasts in their listening.[3]

Forty-four of the 153 farmers who regularly listen to market news broadcasts listen to two programs and eight listen to three. (See Table 2.) An average of 1.39 market news broadcasts are listened to by those farmers who listen to these programs regularly, compared with an average of 1.09 newspapers used by those who regularly read market news.

Obviously, it is not necessary to use only newspapers or radio as exclusive sources of market news. As shown in Table 2, the majority of farmers (63 percent) use both of these mass media as sources of

[3]This conclusion is based on a Chi-square test of goodness of fit. The expected frequencies for readers and non-readers of market news among regular newspaper readers were determined from the proportions of listening and nonlistening to market news programs for regular radio listeners. The result of this test is a Chi-square value of 5.642, which is equivalent to a probability between .02 and .01 for 1 degree of freedom.

TABLE 2—Extent of market news reading and listening

Number of programs listened to for market news	Number of newspapers read for market news			
	None	One	Two	Total
None.....	14	23	3	40
One.....	18	77	6	101
Two.....	13	27	4	44
Three.....	1	7	...	8
Total.....	46	134	13	193

market news. Thirty percent of the remaining group use one of the media; and only 14 (7 percent) use neither radio nor newspapers.

While Michigan farmers make extensive use of those sources which bring market news to them most promptly and accurately, it should be made clear that these data tend to exaggerate the use of these media as sources of market news. The group of farmers selected for study comprises only a small proportion of Michigan farm operators. Although the data necessary for an accurate estimation are unavailable, there is reason for believing that this group comprises less than 5 percent of the farmers. Moreover, throughout the state, the total group of Michigan farm operators is both older and less well-educated than this group.

Since most studies show that older and less well-educated people are less likely to be newspaper readers and radio listeners, it can be expected that the proportions for non-use of either or both newspapers and radio as sources of market news by Michigan farmers are higher than those reported here.

These data also tend to exaggerate the extent of use of these mass media by making it appear as though radio and newspapers offer equivalent services in the presentation of market news. Actually they differ. Radio presents materials more immediately than does the newspaper, whereas the newspaper presents materials in a more permanent form. In this sense, the media have supplementary functions in providing market news.

Newspapers provide comparatively old information which can be studied at one's leisure for as long a time as may be necessary. Radio provides quite recent information which, although it cannot be too

easily retained because of its ephemeral nature, can be very useful when immediate decisions must be formulated. Even in the above average group studied, over one-third of the farmers did not make use of both of these helpful supplementary services.

REACTIONS TO PRESENTATION OF MARKET NEWS BY NEWSPAPERS AND RADIO

All of the farmers who claimed to read newspaper reports of market news regularly were asked for their reactions to six aspects of the paper's handling of those reports. These included dissatisfactions due to difficulties in securing the paper regularly, difficulties in locating the market news reports in the paper, difficulties in reading the reports because of the printing arrangement, omissions in the markets and products covered, and inaccuracies in the prices reported.

Thirty-eight farmers were satisfied with at least one of the newspapers they read for market news. While this included 40 of the 160 paper references, only 9 of the 18 different dailies mentioned at least once as regular sources of market news were not criticized. Only 32 farmers had no complaints with any of the papers that they mentioned as regular sources.

Table 3 shows how the farmers distributed their criticisms among the various papers they read for market news. Apparently, the papers are much more successful in making their market news accessible than they are in including accurate information on those markets which are of greatest interest to their readers.

While none of the papers escaped at least some criticism, some papers were much more successful in satisfying their readers than were others. A comparison of papers A and B in Table 3 will serve to make this difference clear.

Table 4 attempts to rank all of the papers read regularly according to the extent to which their presentations of market news are criticized. Each specific criticism was given a weight of one, and non-reading of market news in a regularly read paper was given a weight of ten on the assumption that this is the most extreme manifestation of dissatisfaction with a paper's handling of market news. The column headed "Critical Score" is derived by dividing the total by the number of regular readers. The higher the score, the higher the extent of criticism.

TABLE 3—Type of criticisms of newspapers read for market news

Newspapers	Farmers reading market news			Criticisms						
	Total	Having no criticisms	Having criticisms	Total	Accuracy of prices	Coverage of markets	Coverage of products	Securing the paper	Locating the reports	Reading the reports
A	36	11	25	45	18	13	9	..	2	3
B	15	..	15	44	12	10	10	7	3	2
C	18	4	14	25	11	6	6	1	1	..
D	18	5	13	25	9	5	5	..	2	4
E	15	4	11	21	10	6	5	..	..	..
F	16	7	9	15	8	4	2	..	1	..
G	6	..	6	14	5	4	4	..	1	..
H	3	..	3	11	3	2	3	3	..	..
I	5	..	5	11	1	3	4	3	..	..
J	3	..	3	9	2	3	2	..	1	1
K	2	..	2	7	2	2	2	1	..	..
L	3	1	2	6	1	2	2	..	1	..
M	7	3	4	6	2	3	1	..	..	..
N	4	1	3	6	..	1	1	3	..	1
O	6	4	2	3	2	..	1	..	..	..
P	1	..	1	3	..	1	1	..	1	..
Q	1	..	1	3	1	1	1	..	..	..
R	1	..	1	2	1	1	..	..	..	..
Total farmers listing papers	147	32*	115	115	88	66	58	15	13	11
Total papers mentioned	160	40*	120	120	88	67	59	18	13	11
No. of different papers	18	9	18	18	16	17	17	6	9	5

*Thirteen of the farmers read two newspapers for market news. Of the thirteen, two have no criticisms of either of the two papers, six have no criticisms of one of the two papers, and five criticise both.

Newspaper	Total reading paper regularly	Total not reading market news	Total reading market news	Number of criticisms of each paper read for market news						Critical score*
				5	4	3	2	1	0	
E	15	..	15	..	..	4	2	5	4	1.27
A	37	1	36	1	..	5	6	13	11	1.48
O	7	1	6	..	..	..	1	1	4	1.86
I	5	..	5	..	..	2	2	1	..	2.20
C	20	2	18	..	..	4	3	7	4	2.25
F	20	4	16	..	1	..	3	5	7	2.75
M	9	2	7	..	..	1	..	3	3	2.89
D	23	5	18	1	1	1	3	7	5	3.26
G	7	1	6	..	..	3	2	1	..	3.43
H	3	..	3	..	2	1	..	..	..	3.67
B	17	2	15	2	2	7	1	3	..	3.88
N	6	2	4	..	..	1	1	1	1	4.33
K	3	1	2	..	1	1	..	..	..	5.67
R	2	1	1	..	..	..	1	..	..	6.00
J	6	3	3	..	..	3	..	..	..	6.50
P	2	1	1	..	..	1	..	..	..	6.50
L	8	5	3	..	1	..	..	..	1	7.00
Q	4	3	1	..	..	1	..	..	..	8.13
S	2	2	..	..	..	..	..	..	..	10.00
T	1	1	..	..	..	..	..	..	..	10.00
U	1	1	..	..	..	..	..	..	..	10.00
V	1	1	..	..	..	..	..	..	..	10.00
Different papers referred to ..	22	19	18	3	6	14	12	11	9	....
Total†	199	39	160	4	8	35	26	47	40	....

*Procedure for computation explained in last paragraph on page 617.

†This is the number of farmers making this number of criticisms. One hundred and ninety-nine dailies were cited as read regularly; 160 of these were read for market news, and 39 were not so used.

The first column of Table 5 contains the rank order of the newspapers for their critical scores. The remaining five columns require explanation. The content of a one-week set of weekday issues of 19 of the 22 papers mentioned as being read regularly was systematically

TABLE 5—Rank of newspapers by criticism and aspects of their content and associations among these ranks

Newspaper*	Ranks for newspaper on					
	Criticism score	Proportion local market news is of all market news	Total Space devoted to local markets on average day	Total space devoted to market news	Degree of emphasis on farm relevant material	Degree of emphasis on locally relevant material
E	1	11	10	12	4	8
A	2	2	3	6	8	5
O	3	8	5	3	9	4
C	4	4	1	1	2	2
F	5	9	9	10	11	7
M	6	3	4	8	12	1
D	7	5	6	14	17	14
G	8	7	8	11	6	3
H	9	16	16	16	1	11
B	10	16	16	15	3	9
N	11	16	16	2	14	19
K	12	16	16	18.5	13	12
R	13	1	2	5	7	6
J	14.5	12	12	7	5	13
P	14.5	16	16	9	18	18
L	16	16	16	18.5	10	10
Q	17	6	11	17	19	16
S	18.5	16	16	13	15	17
T	18.5	10	7	4	16	15
Relationship with rank on criticism:						
Tau†		.15	.18	.21	.37	.47
Probability‡		.40	.29	.23	.03	.005

*Copies of three of the papers were not made available for the content analysis.

†This is Kendall's measure for association between ranks. When the same items have highly similar orders when ranked on two different factors, it indicates a high degree of positive association between the two factors and the value of "tau" approaches +1.00. A "tau" close to .00 indicates no such association. See Hagood, M.J., and D. O. Price (1952). *Statistics for Sociologists*. Henry Holt, New York. pp. 469-472.

‡This is the number of chances in 100 that a "tau" value of the size observed could have been observed when there really is no association. A probability between .05 and .01 is interpreted as meaning that the value of tau is not .00 and is probably significant. A probability of less than .01 also means that "tau" is not .00 and is almost certainly significant.

analyzed. The papers were then ranked according to the following aspects of their content:

1) The proportion of all market news carried by the paper that is devoted to local markets (Column 2).

2) The absolute amount of space devoted to local markets on an average weekday (Column 3).

3) The absolute amount of space devoted to all market news on an average weekday (Column 4).

4) The extent to which items relevant to any aspect of farming are emphasized as a part of the paper's total content (Column 5).

5) The extent to which items relevant to the local communities in the sampled areas of the state are emphasized as a part of the total content (Column 6).

The extent of association between ranking on criticism and ranking on these various aspects of the papers' content is reflected by the statistical measure "tau." The probabilities of finding associations of these magnitudes by chance alone are reported beneath each "tau" (Table 5).

Using the conventionally accepted levels of statistical significance, it may be seen that the association between rankings on criticism and the extent of a paper's emphasis on locally relevant materials is significant beyond all but the smallest measure of doubt. The association between criticisms and the extent of a paper's emphasis on materials relevant to farming is also probably not due to chance, but in this case significance is a great deal lower. None of the other associations come close to a level of statistical significance.

This analysis is of special interest because it suggests that satisfaction with a newspaper's treatment of market news may be understood best with a social psychological approach. To take just one example, many students of the matter suggest that farmers are dissatisfied with mass media market news because there is insufficient coverage of local markets. However, these data show no significant relationship between relative coverage of local markets and degree of criticism. On the other hand, criticism is most significantly related to the extent to which a paper emphasizes all locally relevant materials. This suggests a relationship between community involvement and farming interests, but data for such an investigation are lacking at this time.

The criticisms revealed in this and other studies do include a heavy proportion of complaints about the inadequacy of coverage of local

markets. However, it may be that this is not the basic cause of dissatisfaction. Rather, coverage of local markets may be an easily imagined and easily expressed focus for a more general dissatisfaction with a much less easily comprehended source. If this were the case, dissatisfaction with and associated non-use of market news would not decrease with increased coverage of local markets; but a new, more easily accessible target for criticism would become the outlet for the more incomprehensible dissatisfaction.

It was not possible to pursue as extensive an analysis of the criticisms of market news radio programs as was possible for newspapers. While 108 of the farmers who listened regularly to radio programs had at least one criticism of those programs, 45 did not have any. The kinds of criticisms and the number of farmers expressing each are listed in Table 6.

Criticism of radio market news was not quite as heavy as criticism of that carried by newspapers, but it was more diversified. Mode of presentation by radio was more heavily criticized than it was for newspapers, but content was criticized less. In summary, some degree of dissatisfaction with the way in which each media handles market news seems to be the rule rather than the exception.

Part of the explanation for this relatively intense criticism may arise from the disparity between the market news offered through these media and the farmers' conceptions of what market news is. This interpretation is suggested by the answers given when asked if additional sources of market news were also used. One hundred and

TABLE 6—Criticisms of market news programs listened to on radio

Type of criticism	Number of farmers criticizing
Accuracy of prices reported	67
Announcer's tone of voice	46
Coverage of markets	35
Coverage of products	33
Time of broadcast	28
Station reception	15
Announcer's rate of speaking	5
Other	15
Farmers criticizing	108
Programs criticized	155
Farmers not criticizing	45
Programs not criticized	58

TABLE 7—Additional sources used by farmers for market news

Additional source	Mass media used for market news				
	Both radio and newspaper	Radio only	Newspaper only	Neither	Total
None	31	5	9	5	50
Dealers	61	16	11	5	93
Magazines	34	14	7	5	60
Neighbors and friends	16	3	1	1	21
County agents, etc.	4	3	1	2	10
Well-informed local people, gov't emp., MSU publications, etc.	4	1	2	..	7

forty-three farmers reported using at least one of the additional sources listed (Table 7).

These additional sources provide information beyond that provided by the market news reporting service. Magazines, for example, are largely sources of outlook information. While most additional sources may provide price information, it is certain that each is a source of such additional materials as outlook and/or advice as to where and when to sell. Moreover, none of them can be considered to be as basically reliable as newspapers and radio in reporting current markets. They are likely to lack the speed and accuracy of the mass media.

The most obvious inference to be drawn from these data is that Michigan farmers include outlook information, recommendations on proper selling, and highly specific information which takes into account their personal situation as part of their conception of market news. Moreover, the character of some of these additional sources suggests that this information refers to materials used in production as well as products sold. A market news reporting service might consider these conceptions in its programming.

ONE EXPLANATION OF VARIATIONS IN THE USE OF NEWSPAPERS AND RADIO FOR MARKET NEWS

Why is it that all farmers who are able to read and listen do not avail themselves of these readily accessible sources of useful information about markets for farm products? Undoubtedly, there are a wide variety of factors operating to encourage non-use. Moreover, it is quite possible that the reasons which may be given verbally are only

conscious rationalizations of factors that a man may be unable to recognize. In this project, it was impossible to assess all of the possible factors that may operate in different cases to promote non-use.

However, certain theories that are useful to sociology provided leads to one possible explanation of non-use. It was possible to collect the necessary information to check on the possible relevance of this one factor for explaining variations in the use of the radio and newspaper as sources of market news.

Farmers differ in the extent to which they are committed to farming as a source of livelihood. This commitment is reflected in such diverse forms as the size of the farming operation, the proportion of total income that is derived from nonfarm work, the kind of social relationship that is maintained with dealers, and the extent to which formal supplementary farm information resources are used.

In an analysis reported elsewhere,[4] it was shown that farmers who maintained quite intimate associations with their dealers, and who tended to use such formal farm information sources as double entry bookkeeping, experiment station publications and government agricultural personnel, had the greatest commitment to farming. Those who only saw their dealers on business and did not make use of the above sources of information had the least commitment. Farmers who either maintained close social relations with their dealers or who sought information from these formal sources but did not do both were designated as having a degree of occupational commitment falling between these two extremes.

The use of newspapers and radio as sources of market news by members of each of these three groups was examined, and the results reported in Tables 8, 9 and 10. In every case, the use of mass media as sources of market news is positively and significantly related to the

[4]Smith, Joel (1954). *Op. cit.* Chapter 4.

TABLE 8—Degree of occupational commitment and use of newspapers for market information

Uses newspapers for market information	Degree of occupational commitment			
	Highest	Average	Least	Total
Yes	43	66	34	143
No	6	17	22	45
Total	49	83	56	188

$x^2 = 11.459 \sim p < .01$ (d.f. = 2)

TABLE 9—Degree of occupational commitment and use of radio for market information

Uses radio for market information	Degree of occupational commitment			
	Highest	Average	Least	Total
Yes	45	69	37	151
No	4	14	19	37
Total	49	83	56	188

$x^2 = 11.480 \sim p < .01$ (d.f. = 2)

degree of occupational commitment. The greater the commitment, the greater the extent of use.

This raises the possibility of another line of attack on the problem of maximizing the use of these sources by farmers. Since commitment generally is accompanied by a sense of involvement, perhaps it might be possible to create a greater interest and consequent use of radio and newspaper market news by creating a greater sense of the importance of a man's activities as a farmer. It is not necessary to encourage farmers to increase the size of their farm operations, but it does suggest that an effort should be made to increase the sense of importance that is attached to farming activities.

It is quite possible that no great increase in the use of newspapers and radio for market news will result from changes in the way these

TABLE 10—Degree of occupational commitment and use of mass media for market information

Media used for market information	Degree of occupational commitment			
	Highest	Average	Least	Total
Radio and newspapers	39	57	23	119
Radio only	6	12	14	32
Newspapers only	4	9	11	24
Neither	..	5	8	13
Total	49	83	56	188

$x^2 = 18.950 \sim p < .01$ (d.f. = 4)*

*The "newspaper only" and "neither" groups were grouped in the computation of Chi-square because of low theoretical frequencies. The Chi-square value for the table as it is reported is 21.363, which is also well beyond the .01 level for 6 degrees of freedom. A test of the difference between the proportion of farmers using both media who have the least degree of occupational commitment and the proportion using neither of the media who are of this type resulted in a "t" of 3.376. This difference is well beyond the .01 level and shows the significant tendency for farmers using neither of the media to have the lowest occupational commitment.

media present these materials unless there is an accompanying effort to increase the farmer's sense of involvement with his occupation. If there is merit to this explanation, to the extent that part-time farming is increasing and is associated with a low degree of involvement, an accompanying increase in the non-use of market news may be expected.

SUMMARY

This report is a review of a study of the extent to which Michigan farmers make use of the market news reports brought to them by the newspapers and radio stations of the state. Findings are based on information obtained in 193 interviews with Michigan farmers between the ages of 35 and 44 years old who had some high school but no college education. No attempt has been made to generalize these findings to all of the state's farmers.

The following are among the more important findings:

1. Of the sample of farmers studied, 24 percent did not read market news in newspapers. However, only 11 percent of the **regular** newspaper readers did not read market news regularly.

2. Of the farmers in the total sample, 21 percent did not listen to any market news radio programs regularly. Nineteen percent of those who listened to the radio **regularly** did not listen to market news programs.

3. A greater percent listened to more than one radio program for market news than read more than one newspaper for this purpose.

4. Most of the farmers in the sample used both the newspaper and radio for market news; 63 percent used both, 30 percent used only one, and 7 percent did not use either.

5. Only 22 percent of the farmers who read market news were completely satisfied with the handling of this news in all of the papers they read for this information. The papers that were not criticized included 9 of the 18 different dailies reported as being read for this purpose. Only 25 percent of the 160 papers in which market news was read were not criticized in some way.

There was wide variation in the amount of criticism of each of the 18 papers. The degree of criticism of a paper's handling of market news varied directly with the emphasis that the paper placed on **all** locally relevant materials. The more a paper stressed items of **any** local relevance, the lower was the degree of criticism of the paper's treatment of market news.

6. Nearly 30 percent of the 153 farmers who got market news through radio expressed no criticism of the programs they listened to regularly for this purpose. Only 27 percent of all the programs reported were not criticized to some extent.

7. Seventy-four percent of the sample members reported that they used additional sources for market news. The nature of these additional sources suggests that the conception of market news held by these men included more than information on current prices and supplies. These conceptions probably extended to information on outlooks and advice on marketing, and referred to products bought as well as sold.

8. In attempting to explain variations in the use of mass media as sources of market information by Michigan farmers, it was found that use was directly related to commitment to farming for a livelihood. Commitment refers to actual rather than psychological involvement in the occupation, and was indicated by the type of social relationship which a farmer maintained with his dealer and the extent to which a farmer used formal sources of farming information.[5] In the group with the greatest occupational commitment, all farmers used either both or one of the media. As commitment decreased, use of both media decreased, and non-use of either medium increased.

APPENDIX

The Department of Sociology and Anthropology has been interested in the social aspects of communication for some time. Among pertinent writings are the following: Hoffer, C. R. (1939). Interests of rural people as portrayed in weekly newspapers. Mich. Agr. Exp. Sta. Spec. Bull. 298. 30 pp. Lowe, C. H. and King, R. (1948). How Michigan farmers use poultry marketing information, Mich. Agr. Exp. Sta. Quart. Bull. 31:109-114. Smith, J. (1950). The characteristics of magazine audiences — a survey of the literature. Thesis for degree of M. A., Columbia University, New York City. (Unpublished). Beegle, J. A. (1953). Mass media of communication. Chap. 13, pp. 295-320, in C. P. Loomis, et al., *Rural Social Systems and Adult Education*. Mich. State Col. Press, East Lansing. 392 pp. Smith, J. (1954). Organization of the farm and mass communication. Thesis for the degree of Ph.D., Northwestern University, Evanston. (Unpublished). Work in this area is being pursued by J. A. Beegle, W. Brookover, W. H. Form, D. L. Gibson, L. Haak, C. P. Loomis, J. Smith, C. Sower, G. P. Stone, and G. Taggart. Their work includes studies of the importance of different systems of communication in the decision making process of farmers, the role of mass media in rural adult education, the function of mass media in providing information about community action processes, and the influence of various types of communication in the formation of clothing preferences.

[5]Smith, Joel (1956). The structure of farming operations and mass communications. Mich. Agr. Expt. Sta., Sociology and Anthropology Dept. (Unpublished)

ECONOMICS OF HAULING vs. GRAZING OF FORAGES ON MICHIGAN DAIRY FARMS[1]

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MANY DAIRY FARMERS are becoming increasingly aware of the need for improving both the production and the utilization of green forages in the summer period. A few Michigan dairy farmers have tested out relatively new pasture systems such as direct-chopping and hauling of forages, and strip-grazing. A study started in 1954 and continued in 1955 has attempted an analysis of farms using different pasture or forage management techniques.

This report summarizes the second year's study of the practices used, and investments, expenses and net income associated with alternative pasture management systems.

RESEARCH METHODS USED

The 1955 study included 10 dairy farmers who chopped and hauled most of the forage crops for their cows during the pasture season. These 10 were paired with an equal number who grazed their livestock. Only those dairymen who were using better-than-average management practices were included. The farms were located in Barry, Eaton, Ionia, Kalamazoo, Lenawee and St. Joseph Counties.

Green-chopping and strip-grazing operations were observed on a limited number of farms in both Minnesota and Wisconsin.

Complete information was obtained from each dairyman on: (1) The livestock kept, (2) the cropping system he followed, (3) the acres of each kind of forage, (4) forage harvesting, storage and feeding practices used, (5) labor, power and equipment requirements and expenses in harvesting and feeding forages, (6) daily weights of milk sold, (7) freshening dates of all cows, and (8) other information about the operation of each farm.

[1]Most of the field work was done by Dean Tribby. The author acknowledges the helpful suggestions received from C. M. Harrison of the department of farm crops, W. W. Snyder of the department of dairy, R. G. Wheeler of the department of agricultural economics and R. G. White of the department of agricultural engineering. The author also wishes to express his appreciation to the dairy farmers who cooperated in the study.

ARTICLE 38-68

Fig. 1. Farmers who chopped and hauled forages used 25 percent less acres per cow of both first and second crop meadows than did the farmers who grazed their cows.

CHARACTERISTICS OF THE FARMS STUDIED

Dairying was the major enterprise on all 20 farms studied and most of the crops produced, except wheat, were fed. The farms where forages were green-chopped averaged 34.4 cows compared to 31.4 cows on farms where grazing was practiced. Size of herd ranged from 19 to 72 cows on the farms where forages were chopped and hauled, and from 22 to 43 cows on the farms where forages were grazed. All 20 herds were predominately Holsteins.

Forage crops accounted for 60 percent of the crop acres on both groups of farms. Almost 90 percent of these forage crops were alfalfa-brome (Table 1). The acreages of corn silage and feed grains were about the same for both groups of farms. The farms on which forages were grazed averaged 10 acres more of wheat and 27 acres more of total cropland.

THE 1955 PASTURE SEASON

It was observed that the more progressive dairy farmers often adjusted their pasture practices from year to year. These adjustments were made necessary because of changes in rainfall, temperature and other climatic conditions, and in the kinds and qualities of forage crops produced.

TABLE 1—Average acreages of forages, feed grains and other crops produced, two groups of farms on which forages were hauled or grazed, 1955

Cropland used for:	Farms on which forages were:	
	Hauled	Grazed
Forage		
Alfalfa-brome	79.1	92.6
Red clover	2.9	9.0
Sudan grass	7.5	2.7
Rye	2.0*	2.5*
Total	89.5	104.3
Corn silage	12.2	13.1
Corn for grain	19.6	22.8
Oats and barley	24.0	22.7
Wheat	4.6	14.6
Total cropland	149.9	177.5

*Rye was used for early grazing and then plowed down for corn or sudan grass.

The latter half of the 1955 season was very short of rainfall with above average temperatures prevailing. Thus, many dairymen supplemented green forage with hay, silage and chopped corn for longer periods than normal. Hay and silage feeding was started by two farmers in June and seven in July. Five additional farmers were feeding supplementary forage during August. All 20 farmers were feeding variable quantities of hay, silage or chopped corn during September.

Of the farmers who chopped and hauled forages, four grazed their cows for a limited period at the start of the season and nine grazed them during September. The 10 farmers chopped and hauled forages for an average of 102 days. This is 9 days less than the 1954 average. The chopping period in 1955 ranged from 82 to 140 days on individual farms.

The pasture season averaged 157 days on the 10 farms where grazing was praticed. However, only a limited amount of feed was obtained from some of the pastures during August and September.

The farmers who chopped and hauled forages to their cows supplied each cow with slightly more than one-fourth acre of full-season pasture and two-thirds acre of first crop chopped material (Table 2). Six of these 10 farmers used a combination of alfalfa-brome and

TABLE 2—Average acres of different forage crops utilized during summer feeding period, 1955

Forage crops used:	Farms on which forages were:			
	Hauled		Grazed	
	Acres per farm	Acres per cow	Acres per farm	Acres per cow
First crop meadows				
Pasture	9.4	.27	38.6	1.23
Chopped forage	23.5	.68	....	....
Grass silage	2.1	.06	5.1	.16
Hay	2.4	.07	1.8	.06
Total	37.4	1.08	45.5	1.45
Second crop meadows				
Pasture*	23.0	.67	54.2	1.71
Chopped forage	19.3	.56	....	....
Total	42.3	1.23	54.2	1.71
Chopped corn	1.5	.05	1.7	.05

*Includes forages grazed entire season as well as those grazed only after the first crop had been harvested.

sudan grass for the chopped material. The other four farmers chopped alfalfa-brome as the only summer feed.

A total of slightly more than 1 acre of first crop and 1¼ acres of second crop meadows was supplied to each cow by the farmers who chopped and hauled forage crops. This included the harvested forage fed as grass silage and hay.

The farmers who grazed their cows used an average of 1¼ acres of first crop pasture per cow (Table 2). Most of this acreage was used for pasture the entire season. Pastures were supplemented with grass silage on seven farms and with hay on four farms. A total of nearly 1½ acres of first crop forages was supplied per cow. The farmers who chopped and hauled forages used 25 percent less acres per cow of both first and second crop forages.

FORAGE EQUIPMENT AND INVESTMENTS

The 10 dairy farmers who chopped and hauled feed harvested 44 percent of their forages intended for the barn-feeding period as grass silage. The 10 farmers who grazed their cows harvested only 17 percent of their winter feed as grass silage.

The farmers who chopped and hauled forages had a total of $1,200 more invested in forage harvesting and feeding equipment than the farmers who grazed their forages (Table 3). Five of these 10 farmers owned both baling and chopping equipment. One farmer owned two choppers to avoid a conflict in the use of equipment when grass silage and hay were being harvested.

Of the farmers grazing their cows, four owned chopping equipment, three owned baling equipment, two owned both chopping and baling equipment, and one farmer hired the chopping of hay, grass and corn silage.

Investment in self-feeding wagons and feed bunks added $330 to investments on the farms where forages were chopped and hauled. One farmer constructed a 30 by 100-foot concrete slab on which to feed chopped material. This slab cost $500 to build. Muddy feed lots and flies were problems on many of the farms. Several of these farmers planned to build concrete feeding floors in the future.

MILK PRODUCTION RESPONSE

A change from barn to pasture feeding usually results in increased production of milk per cow. This is probably due to the more nutri-

TABLE 3—Investment in forage harvesting equipment, 1955

Equipment*	Farms on which forages were:			
	Hauled		Grazed	
	No. farms with this equipment	Present value (average for farms owning)	No. farms with this equipment	Present value (average for farms owning)
Baler	5	$ 978	5	$1,038
Field chopper	10‡	1,421	5	1,076
Blower	8§	419	5	306
Chopper wagons	10	470	5	441
Self-feeding wagons	9	165	...	...
Flat wagons	6	130	5	234
Feed bunks	1	165	...	...
Total investment†	...	$2,895	...	$1,679

*Includes equipment for harvesting hay, grass and corn silage, and additional equipment needed in feeding chopped material.

†Average value for all farms.

‡One farmer had two choppers. This makes a total of 11 choppers on these 10 farms.

§Two farmers used a blower attached to wagon.

Fig. 2. Home-made self-feeding wagons were used by eight of the farmers who were green-chopping forages.

tious nature of the material as well as to the greater palatability. Chemical analyses made of this material at the start of the season show a high-protein, low-fiber feed.

Milk production responses were measured on the 20 farms comparing actual daily production (on a weekly basis) of the herd with a computed expected daily production. The expected production was computed by assigning weekly values for each cow's lactation period. For example, a value of 100 was given to the fourth week's expected production. A peak in a cow's milk production is usually reached in the fourth to the sixth week of her lactation period. As a cow's lactation period progresses, these values become smaller and smaller until they reach zero at the end of her milking period. A value of six was used for the last week's production.

These weekly values for all cows in each herd were totalled. An index of daily expected production (on a weekly period) per cow was then computed, with the barn period average considered as 100. The actual daily production (on a weekly period) per cow was then calculated. These daily average weights of milk were then converted to an index of actual production, with the average for the barn period considered as 100.

The expected production for the entire period is shown as a straight line (100). The weekly variation in actual production from

the expected production reflects changes in the quality and quantity of feeds, as well as changes in climatic and other environmental conditions. This method of measuring milk production response will be used in the next section.

MOST SUCCESSFUL FARMS

The dairymen who were most successful in using improved forage management practices during the summer period were selected for special study. Six of these were dairymen who grazed their cows and four were dairymen who chopped and hauled forages for their cows.

The production response of cows in individual herds varied widely when chopped material or pasture was substituted for barn-fed forages. A comparison was made of the milk production responses of cows on the six farms where the most successful chopping systems were followed, and on the four farms where the most successful grazing practices were used.

Actual production for both groups of farms followed similar trends during the winter-feeding period. Daily milk production was greatly stimulated when the pasture season started and reached a peak about May 20-25 for both groups of cows. This trend in daily milk produc-

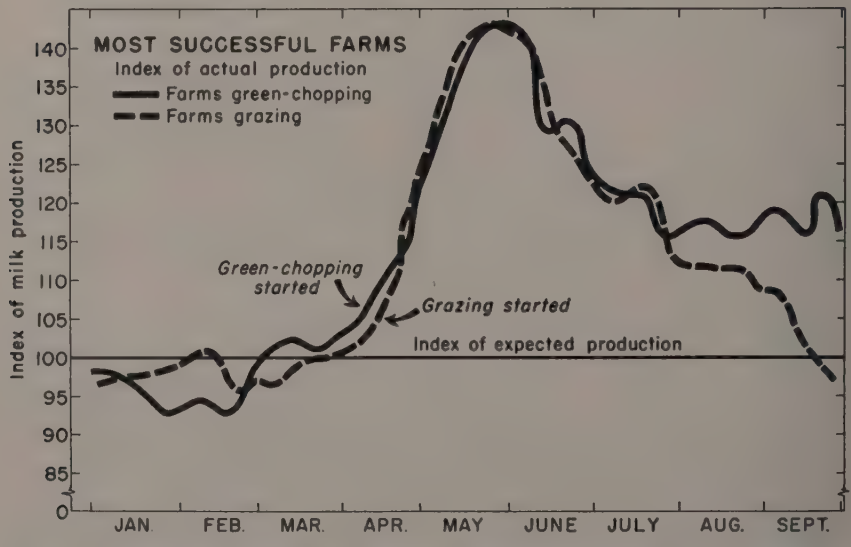

Fig. 3. Index of actual and expected weekly production on farms where forages were green-chopped and grazed. Average of most successful farms, 1955.

tion showed a similar downward trend from May 25 to about July 20 (Fig. 3).

From this date on through August and September, daily milk production leveled off on the farms where forages were chopped and hauled at about 15 percent above the average for the barn-period. The downward trend in daily milk production continued to the end of

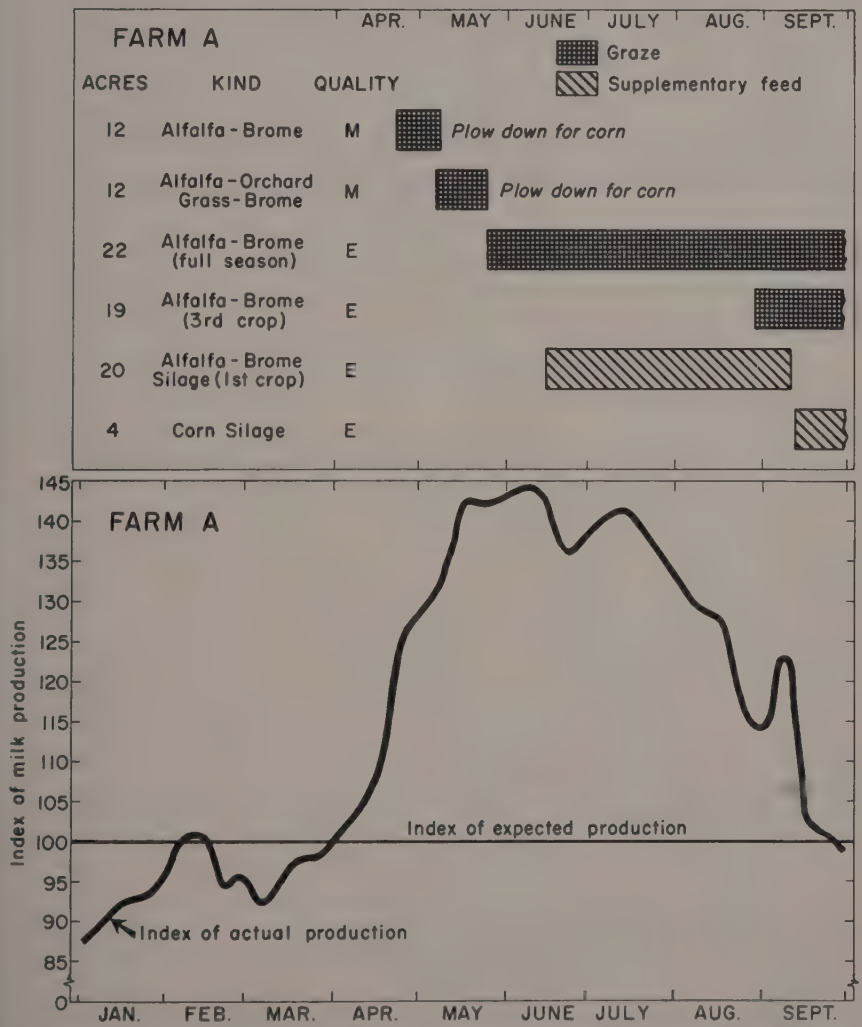

Fig. 4. Index of actual and expected daily production of milk per cow, Farm A. (Quality rating: E = Excellent, M = Medium, P = Poor).

Fig. 5. Most dairy farmers will benefit more by improving their grazing practices than by shifting to a system of green-chopping or strip-grazing.

September on the farms where grazing was practiced. Milk production didn't drop during August and September for the farms where forages were chopped because of the heavier supplementary feeding of silage and hay.

INDIVIDUAL CASE STUDIES

Farmer A—This farmer was extremely successful in using improved grazing practices. Milk production was maintained at a high level during the entire pasture season (Fig. 4).

The grazing period started on April 21 when the 44 Holstein cows were turned into 12 acres of alfalfa-brome and orchard grass. Cows grazed this field until May 3 when it was plowed for corn. A second 12-acre field was grazed until May 17 when it was also plowed down for corn. From May 18 through September, the cows grazed an excellent stand of 22 acres of alfalfa-brome grass pasture. This field provided very little grazing during September. Nineteen acres of third crop alfalfa-brome grass were also grazed during September.

The cows on this farm were fed grass silage for an 86-day period, starting June 16, at the rate of about 55 pounds per cow daily. Twenty acres of early harvested grass silage were fed during this period. The cows were fed corn silage at the rate of 70 pounds per day per cow the last 20 days of September.

If the 20-acre field of alfalfa-brome grass had been grazed the entire season along with the 22-acre field instead of fed as grass silage, it is almost certain that milk production would have dropped drastically during late July, August and September. This farmer supplied each cow with ½ acre of full-season pasture and nearly ½ acre of early harvested grass silage.

All of the harvested hay, grass and corn silage on this farm were chopped. Part of the hay was barn-dried. This dairyman was doing a better than average job in producing and feeding good quality forage. Grain was fed at the rate of about 1 pound to 4 pounds of milk produced. A milk production average of better than 10,000 pounds per cow annually has been attained on this farm.

Farmer B—This farmer was also very successful in using improved summer feeding practices. In contrast to Farmer A, he chopped and hauled forage crops to his cows for most of the season. He did start the season by grazing a 9-acre alfalfa-brome grass field for a 20-day period starting May 10. This field was quite rolling and thus not well-suited for chopping.

Three separate fields supplied all of the chopped forage fed daily during June, July and August. Forage from an 11-acre alfalfa-brome grass field was chopped and hauled to the cows for 37 days, starting June 1. This stand contained 50 percent brome grass and, thus, was rated as medium in quality. The forage from this field became quite mature by the end of June, at which time it appeared to depress daily milk production (Fig. 6).

An excellent stand of first crop alfalfa-brome grass—Ladino clover was used for chopped feed for a 21-day period (July 7-27). Daily milk production was stimulated considerably when the cows were fed this high-legume forage.

The third field consisted of 18 acres of sudan grass. Ordinarily, sudan grass would be 18 to 24 inches in height when it was first chopped. Abnormally hot weather during July stimulated growth to such an extent that the sudan grass was 4 to 5 feet high and partially headed out by late July. Half of this field was chopped for grass silage about July 27. This forage tested 14 percent protein on a dry matter basis when it went into storage. The remaining 9 acres were chopped and hauled to the cows for a 21-day period.

Second crop forage from the three fields provided the green feed during the balance of August. Cows were grazed on 60 acres of

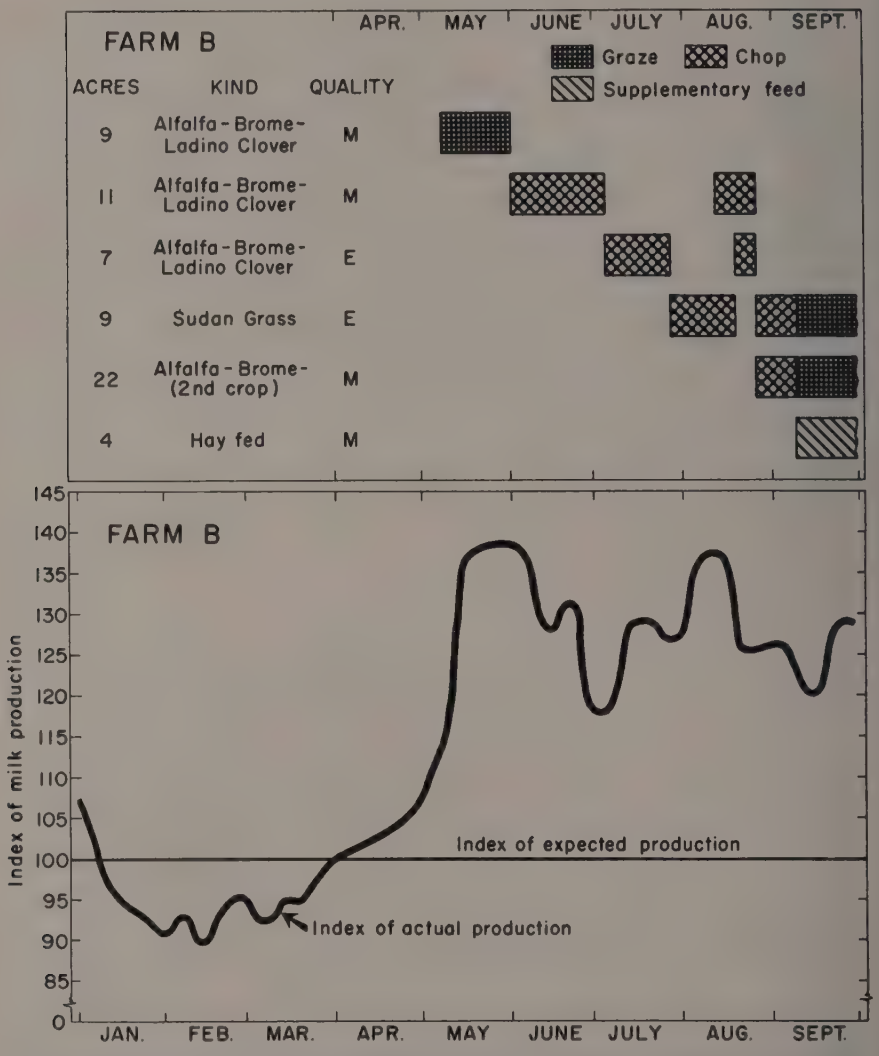

Fig. 6. Index of actual and expected daily production of milk per cow, Farm B. (Quality rating: E = Excellent, M = Medium, P = Poor).

third-crop meadows during September. Hay was fed at the rate of 5 pounds per cow daily the last 15 days of September.

Milk production held up remarkably well all season although it tended to fluctuate more than on Farm A. Under more normal weather conditions, chopping operations would have continued at least through part of September.

Fig. 7. Harvesting and storing 1½ to 2 tons of grass silage per cow for mid-summer feeding is a profitable practice. Feed bunks such as these were used for both green-chopped forages and grass silage.

One of the outstanding differences between Farms A and B is the acres of cropland. There are 212 acres of cropland on Farm A compared to 112 for Farm B. Farmer B is now using the entire 112 acres for the production of forage crops. He is forced to do this if he is to carry 34 cows and the additional young stock. Since this farm is devoted entirely to the production of alfalfa-brome grass and sudan grass, there are no conflicts with corn, grain or other crops for the use of power, machinery and labor in daily chopping operations. All grain needed for the cows is purchased. This dairy farmer has also averaged more than 10,000 pounds of milk produced annually from his Holstein cows.

Farmer C—This represents a farm situation in which medium to poor quality forages are produced. Daily milk production was greatly stimulated at the start of the pasture season when pastures are usually high in feeding value regardless of the species in the stand. Daily milk production per cow dropped rapidly in early to mid-June and was often below the barn-feeding period average during the remainder of the grazing season (Fig. 8).

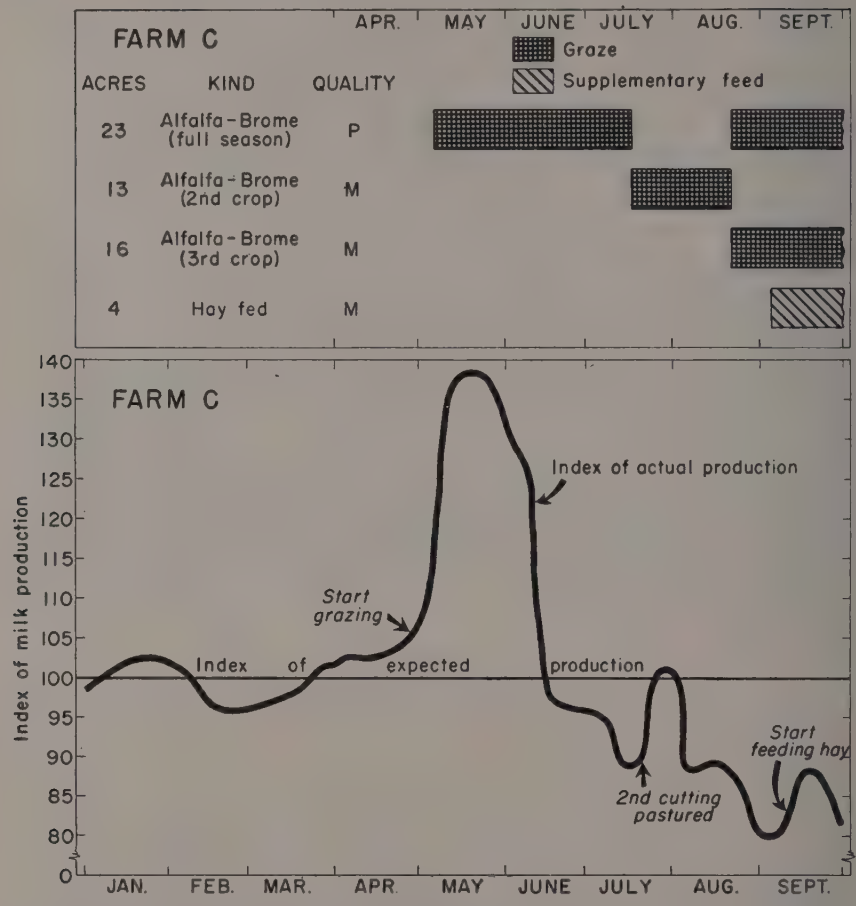

Fig. 8. Index of actual and expected daily production of milk per cow, Farm C. (Quality rating: E = Excellent, M = Medium, P = Poor).

This failure to maintain daily milk production at high levels was due primarily to two factors: (1) Poor quality forages grazed and (2) inadequate use of grass silage, hay or chopped corn to fill in gaps in pasture production.

Pasture fields high in brome, quack and other grasses mature more rapidly than stands high in legumes, and they become woody and low in feeding value early in the season. A recent study of the factors affecting the feeding value of forages showed that forage stands predominately grass often tested as low as 10 percent protein

by June 20.[2] Forage stands high in legumes would test from 15 to 20 percent protein by this date.

Direct chopping and hauling of poor quality forages does not improve quality or materially increase production per acre. Chopping operations have been a complete failure on some farms because of poor forage production. These farmers often had little or no material to chop after the middle of July.

WHICH SYSTEM IS MOST PROFITABLE?

Dairy farmers can expect to decrease the acreage of pasture crops needed by as much as 25 to 30 percent by chopping and hauling forages. But a farmer needs to consider the year-long feed requirements when he calculates the economic returns for different pasture systems.

How profitable daily chopping and hauling of forage crops to cows will be depends on the timely use of the forage saved. The extra forage saved might be used to feed the cows a more adequate quantity of forage either during the pasture or barn-feeding periods. Or it could be used to feed more cows. Many farmers are now purchasing hay to supplement their own supply. Other dairy farmers feed extra grain and protein because they are short of forage or because forage quality is poor. Still other dairymen could add more cows to utilize the forage saved.

One southern Michigan dairy farmer with 120 acres of productive cropland can produce all the forage and grain needed during the year for 33 Holstein cows and young stock when pastures are grazed. If this farmer shifted to a well-managed chopping and hauling program, he could produce forage for at least three more cows and one replacement heifer.

A shift from continuous grazing to green-chopping would add $1,000 to new investment on this 120-acre farm. If this farmer had been baling hay instead of chopping hay and silage, his investment would have been increased by $3,200.

Milk sales per cow now average 9,000 pounds of 3.5 test milk. The milk from the three additional cows would add $1,036 to receipts, based on a price of $3.80 per cwt. Sale of cull cows and calves would add $90, bringing additional receipts to $1,126 (Table 4).

[2]Hoglund, C. R.; E. J. Benne, L. V. Nelson, and C. F. Huffman (1956). Forage quality and protein feeding of dairy cows. Mich. Agr. Expt. Sta. Quart. Bul. 38: 413-430.

TABLE 4—Estimated changes in receipts, expenses and net income resulting from a shift from continuous grazing to green-chopping of forages (120-acre productive cropland farm, southern Michigan)

Item	Net effect of change
	Dollars
Additional receipts*	
Milk (3 x 90 cwt. x $3.80 cwt.)	1,036
Cull cows and calves	90
Total	1,126
Additional expenses*	
Grain	176
Protein supplement	50
Buildings and equipment	40
Miscellaneous dairy ($30 per cow)	90
Equipment operation and maint.†	350
Labor	(150)
Total	706
Reduction in fencing expense	−75
Net increase in expenses	631
Increase in net income	495

*Based on 1955 prices.

†Includes cost of fuel, oil, depreciation, insurance, etc. for extra investments and extra operations in chopping and hauling feed.

It would be necessary for this dairy farmer to purchase the grain and protein needed by the three extra cows and replacements. The additional grain would cost $176 and the protein supplement $50. D.H.I.A., breeding, veterinary and other miscellaneous expenses would add about $30 per cow or a total of $90. Remodelling the barn and adding additional equipment for three extra cows would add $40 to annual expenses. Daily chopping and hauling of pasture crops would add $350 to annual costs when the green-chopping system is used. A system of green-chopping might make it possible to eliminate cross-fences on some farms. It has been estimated that an annual saving of $75 would result.

Shifting from continuous grazing to green-chopping would increase net expenses by $631 and net income by $495. An individual farmer will need to consider whether he can afford to spend from 30

Fig. 9. Strip-grazing is a relatively new practice which may be profitable on some farms in Michigan. Cows are moved to a new strip each day.

to 90 minutes daily in chopping and hauling pasture crops to his cows. Will his labor earn him more when it is used on other enterprises?

A dairy farmer will also need to consider whether the additional investment needed in shifting to a green-chopping system might earn more money when invested in more or better cows, more fertilizer, or a number of other alternatives.

It is doubtful if the system of green-chopping will be profitable unless a dairy farmer has 30 or more cows and has few conflicts for the use of his labor, power and chopping equipment during the pasture period.

Strip-grazing is a relatively new practice which may be profitable for some dairy farmers. The pasture acreage needed per cow can be decreased by the same percentage when either strip-grazing or green-chopping are substituted for continuous grazing.

A major advantage of strip-grazing over green-chopping is that very little change would occur in investment. The cost of harvesting forages would be increased only to the extent of the extra feed needed during the barn-feeding period. There would be some additional fencing expenses.

Most dairymen will gain the most from improving on the grazing practices they now use. This may mean obtaining better stands and keeping them productive by using more lime and fertilizer, the harvesting and storing of increased quantities of grass silage, and making greater use of other improved management practices.

THE FRED RUSS FOREST CUTTINGS -- A PROGRESS REPORT

By VICTOR J. RUDOLPH and C. INGERSOLL ARNOLD[1]

STANDS OF OAK and mixed hardwoods constitute the major portion of the forested area in the southern half of Michigan's lower peninsula. Most of this forested area is owned by farmers. There is not enough information on how best to manage these stands for the most economical production of the maximum volumes of forest products. Tentative recommendations for managing stands of oak and mixed hardwoods have been listed in a recent preliminary report, but they are based largely on generalized observations.[2]

RESEARCH STARTED ON FRED RUSS FOREST

In the fall of 1952, a long-term research project was started in a 40-acre portion of an old-growth oak-mixed hardwood stand in the Fred Russ Forest, located near Dowagiac in Cass County, Michigan. The objective of the study is to determine the suitability of various cutting methods and other management techniques to hardwood stands in southern Michigan. Results of different management practices will be compared with respect to the following items:

1. Reproduction obtained following cutting; its adequacy, composition, and the subsequent development of its desirable and undesirable species components.
2. Growth of the residual stand following cutting, by tree sizes and species, in volume, quality and value.
3. Output of timber products under various management techniques, in terms of volume, quality and value.
4. Losses of trees and volume through mortality, both natural, and attributable to the different kinds of management activity.

[1]Assistant professor, Department of Forestry, Michigan State University; and resident forester, Fred Russ Forest, respectively.

[2]"Recommended Forest Practices For the Principal Forest Types of Lower Michigan". Tentative report prepared by Forest Practices Committee, Lower Michigan Chapter, Central States Section, Society of American Foresters. Unpublished mimeo. material. 1953.

ARTICLE 38-69

The 580-acre Fred Russ Forest was donated to Michigan State University in 1942 by the late Fred Russ, of Cassopolis, Michigan. In addition to some forest plantations, an operating forest tree nursery and some second-growth hardwood stands, the area has approximately 160 acres of old-growth mixed hardwoods which had been left in a relatively undisturbed condition for approximately 100 years. A very light cutting, taking out a few selected black walnut trees, was made about 1900. A second very light cutting, removing a few select white oak trees, was made in 1941.

The topography of the area is gently undulating, and drainage is provided by Dowagiac Creek. The soil is of glacial origin from sandy drift, and is classified as Miami sandy loam. The accumulation of litter on the soil surface was 2 to 4 inches deep. There is no record of any grazing use of the area, and apparently no damaging fires have occurred on the area for a considerable period of time.

Examination of the stumps of trees felled in subsequent cutting operations did not reveal any scars of past fires; however, it is quite likely that the establishment of the present stand some 150 to 200 years ago, particularly its oak component, followed a severe fire or similar major catastrophe. An adequate seed source of the oaks must have been present, so that a predominantly even-aged stand of mixed oaks became established on the disturbed and exposed area.

At the time this study was begun, tree reproduction over most of the area was sparse (Fig. 1). Sugar maple seedlings were most abundant, although the majority of them were of poor form and vigor. Where an occasional large tree had died or had been cut, a small clump of more vigorous seedling was often present in the opening thus created.

For the purposes of this study, the 40-acre area was divided into 20 plots of two acres each. The plot dimensions are four by five chains. An assigned number was painted on each tree 8 inches d.b.h. and larger. Data on trees less than 8 inches d.b.h. were obtained from a 10 percent sample of each plot. The information recorded for each tree consisted of the following:

1. Tree number.
2. Species.
3. D.b.h. to the nearest tenth-inch.
4. Merchantable height in 16-foot logs, to the nearest half-log.
5. Form class.

6. Crown class, by the four standard crown classes (dominant, codominant, intermediate, suppressed).
7. Vigor class, according to the four vigor classes used in classifying northern hardwoods (Goetzen et al. 1943).

Fig. 1. A general view in the area before cutting.

8. Grade of the butt log, by the four log grades used in grading northern hardwood logs (U.S. Forest Service, 1949).
9. Cull defect class, based on the six cull defect classes as developed by the U.S. Forest Service (Zillgitt and Gevorkiantz 1946).

ANALYSIS OF STAND

An analysis of stand conditions on the entire area before cutting (Rudolph, 1956) showed that the three most important species in the stand composition were white oak (*Quercus alba* L.), black oak (*Q. velutina* Lam.), and sugar maple (*Acer saccharum* Marsh.) (Table 1). Sugar maple was increasingly abundant with decreasing diameter, while no oaks below 4 inches d.b.h. were present on the area. Obviously the stand composition had been changing for quite some time, with sugar maple gradually replacing the oaks.

The average gross and net volumes per acre were approximately

16,500 and 14,800 board feet, respectively. The basal area of the stand 8 inches d.b.h. and larger averaged 122 square feet per acre. Some very large trees, many of them extremely defective, were present on the area. The amount of visible defect and decadence increased considerably with increasing diameter.

TABLE 1—Stand table for oak-mixed hardwoods, Fred Russ Forest, Dowagiac, Michigan, 1952

D.B.H. inches	Average number of trees per acre				
	White oak	Black oak	Sugar maple	Misc.*	All species
1	...	...	196.5	64.3	260.8
2	...	...	78.6	38.0	116.6
3	...	...	59.8	28.7	88.5
4	.3	...	39.5	16.1	55.9
5	.3	.3	22.8	6.6	30.0
6	.5	.3	16.8	4.3	21.9
7	.3	...	10.3	2.0	12.6
8	1.2	.5	4.3	2.2	8.2
9	1.6	.7	3.0	1.7	7.0
10	2.4	.7	1.9	1.4	6.4
11	2.1	.8	1.5	1.5	5.9
12	2.3	.8	1.1	1.2	5.4
13	2.4	1.2	1.0	.9	5.5
14	2.1	1.1	.9	.9	5.0
15	1.7	1.2	.5	.7	4.1
16	1.3	1.1	.5	.6	3.5
17	1.8	1.3	.4	.7	4.2
18	1.4	.8	.3	.7	3.2
19	1.2	1.2	.1	.5	3.0
20	1.4	1.1	.2	.2	2.9
21	.9	.6	.1	.5	2.1
22	1.1	.6	.2	.4	2.3
23	1.0	.5	.1	.3	1.9
24	1.2	.5	...	.2	1.9
25	.8	.4	...	.3	1.5
26	1.0	.2	...	...	1.2
27	.8	.2	...	.2	1.2
28	.7	.1	...	.1	.9
29	.7	.1	...	...	.8
30	.7	.1	...	.1	.9
31	.4	...	...	...	.4
32+	1.2	...	...	.2	1.4
Total...	34.8	16.4	440.4	175.5	667.1

*Includes red oak (*Quercus rubra* L.), red maple (*Acer rubrum* L.), yellow-poplar (*Liriodendron tulipifera* L.), black cherry (*Prunus serotina* Ehrh.), American elm (*Ulmus americana* L.), black walnut (*Juglans nigra* L.), white ash (*Fraxinus americana* L.), beech (*Fagus grandifolia* Ehrh.), basswood (*Tilia americana* L.), sassafras (*Sassafras albidum* (Nutt.) Nees), and hophornbeam (*Ostrya virginiana* (Mill.) K. Koch).

For the black oak and sugar maple, the ratio of volume in board feet per square foot of basal area decreased significantly with tree diameters larger than 24 inches. The larger trees of these two species were similar to "wolf trees", with a consequent low merchantable height. The volume-basal area ratio for white oak remained fairly constant, even in the larger sizes. White oak formed the major high quality component of the stand, followed by black oak, with sugar maple having the lowest quality trees of the three most important species.

RESEARCH PROCEDURE

During the 1953-54 winter season, the first cuttings were made on the area. The cutting treatments applied at random to the plots, with four replications of each treatment, were as follows:

1. Relatively light single tree selection cutting, leaving 90 square feet of basal area per acre in the residual stand 8 inches d.b.h. and larger (Fig. 2).

Fig. 2. A view of a plot given a light single tree selection cutting.

Fig. 3. A view of a plot given a heavier single tree selection cutting.

Fig. 4. A view of a plot given a group selection cutting.

Fig. 5. A view of a plot given a shelterwood cutting.

2. Heavier single tree selection cutting, leaving 75 square feet of basal area per acre in trees 8 inches d.b.h. and larger (Fig. 3).
3. Group selection cutting, taking out groups of trees approximating one-tenth-acre in size, leaving a residual basal area per acre of approximately 90 square feet in trees 8 inches d.b.h. and larger (Fig. 4).
4. Shelterwood cutting, removing all but approximately 40 square feet of basal area per acre in vigorous trees of desirable species (Fig. 5).
5. Control, or check plots, on which no cutting was or will be made.

Since these cuttings are the beginning of organized forest management and operation in this stand, each of the harvest cuts included an improvement cutting. Particularly in the group selection method, some very defective or otherwise undesirable trees were removed from portions of the plot not included in the group cutting. Likewise, it was not possible in many cases to remove all such

undesirable and defective trees in the first cut without making it too heavy. The next periodic harvest cuttings will still include improvement cuts.

TENTATIVE ROTATION STARTED

A tentative rotation of 100 years was set with cyclic cuts under the selection methods to be made every 5 years. The plots given the shelterwood cutting treatment are to be examined at the end of 5 years to determine the adequacy of reproduction and the feasibility of making the removal cutting. If reproduction is considered inadequate, the removal cutting may be delayed, perhaps for as long as an additional 5 years.

The regular four-man crew employed primarily for nursery work on the forest performed the felling, bucking, and skidding operations.

TABLE 2—Average stand data for the four plots treated by the light single tree selection method

D. B. H.	Before cutting				Removed in cutting*				After cutting			
	No. of trees per acre	Basal area per acre	Volume per acre†		No. of trees per acre	Basal area per acre	Volume per acre†		No. of trees per acre	Basal area per acre	Volume per acre†	
			Gross	Net			Gross	Net			Gross	Net
in.		sq. ft.	bd. ft.	bd. ft.		sq. ft.	bd. ft.	bd. ft.		sq. ft.	bd. ft.	bd. ft.
8	8.4	2.90	...	...	2.0	.71	...	...	6.4	2.19	...	...
9	7.7	3.36	...	...	2.2	.97	...	...	5.5	2.39	...	...
10	7.7	4.14	292	232	2.2	1.20	69	64	5.5	2.94	223	168
11	8.2	5.44	438	411	1.6	1.07	95	89	6.6	4.37	343	322
12	7.0	5.45	507	475	.9	.67	60	52	6.1	4.78	447	423
13	6.2	5.71	577	542	1.2	1.10	83	77	5.0	4.61	494	465
14	6.0	6.35	760	703	.5	.51	49	40	5.5	5.84	711	663
15	3.8	4.55	544	508	.4	.47	35	30	3.4	4.08	509	478
16	4.9	6.73	908	842	.8	1.00	126	106	4.1	5.73	782	736
17	4.9	7.72	1,062	987	.8	1.19	130	115	4.1	6.53	932	872
18	4.3	7.46	1,008	919	.9	1.52	182	157	3.4	5.94	826	762
19	3.4	6.55	914	833	.8	1.47	180	160	2.6	5.08	734	673
20	3.8	8.16	1,209	1,038	1.5	3.26	480	394	2.3	4.90	729	644
21	2.5	5.99	931	821	.7	1.80	280	229	1.8	4.19	651	592
22	2.5	6.58	1,109	963	1.0	2.65	412	328	1.5	3.93	697	635
23	1.8	5.07	849	718	.8	2.17	351	253	1.0	2.90	498	465
24	1.3	3.97	610	526	.8	2.37	386	343	.5	1.60	224	183
25	1.5	5.02	805	753	.4	1.23	192	177	1.1	3.79	613	576
26	.8	2.74	482	418	.5	1.80	313	254	.3	.94	169	164
27	.8	2.99	477	414	.4	1.51	247	206	.4	1.48	230	208
28	.6	2.68	468	406	.3	1.59	274	234	.3	1.09	194	172
29	.6	2.86	457	347	.2	1.15	196	133	.4	1.71	261	214
30	.9	4.29	613	472	.8	3.69	506	373	.1	.60	107	99
31	.3	1.34	191	163	...	...	...	...	.3	1.34	191	163
32+	1.4	10.88	2,117	1,917	.8	5.88	1,014	856	.6	5.00	1,103	1,061
Total	91.3	128.93	17,328	15,408	22.5	40.98	5,660	4,670	68.8	87.95	11,668	10,738

*Twenty-five percent of the trees in the initial stand were removed by cutting, 32 percent of the basal area, 33 percent of the gross volume and 30 percent of the net volume.

†Volumes are based on Tables 8-33 in Mesavage, C., and J. W. Girard. 1946. Tables for estimating board-foot volume of timber. U.S.D.A., Forest Service.

Because of the experimental nature of the cuttings, complete control over the woods operations by the resident forester and his crew was considered advantageous.

The larger trees were felled and bucked with a two-man power chain saw. The smaller trees were felled and bucked with a one-man power chain saw. The same saw was also used to do as much bucking of the larger logs as possible to avoid carrying the larger and heavier two-man saw through accumulations of slash. A two-man crew was assigned to the smaller saw. The second man did much of the limbing, and assisted generally in the felling and bucking operations.

Because of the experimental aspects of the operations, it was believed undesirable to conduct log-loading operations on the area be-

TABLE 3—Average stand data for the four plots treated by the heavier single tree selection method

D. B. H.	Before cutting				Removed in cutting*				After cutting			
	No. of trees per acre	Basal area per acre	Volume per acre†		No. of trees per acre	Basal area per acre	Volume per acre†		No. of trees per acre	Basal area per acre	Volume per acre†	
			Gross	Net			Gross	Net			Gross	Net
in.		sq. ft.	bd. ft.	bd. ft.		sq. ft.	bd. ft.	bd. ft.		sq. ft.	bd. ft.	bd. ft.
8	8.5	2.91	...	...	2.3	.77	...	...	6.2	2.14	...	...
9	6.9	2.96	...	...	2.5	1.09	...	...	4.4	1.87	...	...
10	5.9	3.16	182	170	1.9	.99	49	45	4.0	2.17	133	125
11	4.6	3.05	232	217	.7	.50	37	32	3.9	2.55	195	185
12	3.6	2.86	243	226	1.0	.81	61	53	2.6	2.05	182	173
13	5.2	4.75	484	452	.9	.90	80	73	4.3	3.85	404	379
14	5.1	5.48	645	605	.7	.80	94	85	4.4	4.68	551	520
15	3.8	4.57	593	561	.5	.62	81	71	3.3	3.95	512	490
16	2.4	3.30	447	425	.8	1.05	143	135	1.6	2.25	304	290
17	3.5	5.50	748	703	.6	.98	108	95	2.9	4.52	640	608
18	3.0	5.32	750	708	.4	.65	84	77	2.6	4.67	666	631
19	3.6	7.09	1,019	954	.5	.96	138	127	3.1	6.13	881	827
20	3.1	6.75	960	889	.5	1.08	137	124	2.6	5.67	823	765
21	2.3	5.43	760	707	.7	1.50	208	187	1.6	3.93	552	520
22	2.3	5.92	867	784	.5	1.29	206	174	1.8	4.63	661	610
23	2.1	6.11	850	735	1.1	3.23	434	350	1.0	2.88	416	385
24	2.3	7.06	1,054	929	1.2	3.53	472	384	1.1	3.53	582	545
25	1.5	5.10	770	668	1.1	3.80	594	505	.4	1.30	176	163
26	.8	2.79	378	321	.4	1.40	173	135	.4	1.39	205	186
27	1.0	3.96	603	538	.5	1.98	311	267	.5	1.98	292	271
28	1.3	5.33	758	649	.5	2.15	289	233	.8	3.18	469	416
29	1.1	5.11	704	602	.5	2.27	293	229	.6	2.84	411	373
30	.5	2.45	322	264	.4	1.85	240	200	.1	.60	82	64
31	.3	1.29	230	211	.3	1.29	230	211	...	...	...	...
32+	.6	4.85	488	409	.4	3.20	360	300	.2	1.65	128	109
Total	75.3	113.10	14,087	12,727	20.9	38.69	4,822	4,092	54.4	74.41	9,265	8,635

*Twenty-eight percent of the trees in the initial stand were removed by cutting, 34 percent of the basal area, 34 percent of the gross volume and 32 percent of the net volume.

†Volumes are based on Tables 8-33 in Mesavage, C., and J. W. Girard. 1946. Tables for estimating board-foot volume of timber. U.S.D.A., Forest Service.

cause there would be greater disturbance of the forest floor in some plots than in others. Therefore, all logs were skidded off the tract and decked on an adjoining area for loading on trucks. This increased the maximum skidding distance, so that in some cases it exceeded one-fourth of a mile. Many of the black oak logs were decked separately for later use in a lumber grade recovery study at the sawmill.

The larger logs were ground-skidded, using either a crawler tractor with a winch, or a rubber-tired farm tractor equipped with a rear-mounted hydraulic lifting device. On the longer hauls, the smaller logs were loaded on a logging sled or "scoot" which was pulled by the crawler tractor.

Existing woods roads and trails were used for skidding whenever possible. However, some additional trails had to be developed in

TABLE 4—Average stand data for the four plots treated by the group selection method

D. B. H.	Before cutting				Removed in cutting*				After cutting			
	No. of trees per acre	Basal area per acre	Volume per acre†		No. of trees per acre	Basal area per acre	Volume per acre†		No. of trees per acre	Basal area per acre	Volume per acre†	
			Gross	Net			Gross	Net			Gross	Net
in.		sq. ft.	bd. ft.	bd. ft.		sq. ft.	bd.	bd. ft.		sq. ft.	bd. ft	bd. ft.
8	9.9	3.41	...	...	1.1	.39	...	...	8.8	3.02	...	...
9	7.6	3.25	...	...	1.0	.43	...	...	6.6	2.82	...	...
10	6.0	3.26	201	186	2.1	1.12	61	53	3.9	2.14	140	133
11	5.4	3.55	283	255	1.4	.90	67	54	4.0	2.65	216	201
12	4.9	3.81	367	342	.7	.60	49	41	4.2	3.21	318	301
13	4.9	4.44	504	472	.6	.58	54	43	4.3	2.86	450	429
14	4.1	4.35	558	531	.2	.26	33	32	3.9	4.09	525	499
15	4.6	5.71	725	671	.8	1.11	116	98	3.8	4.60	609	573
16	3.1	4.36	622	588	.2	.36	27	23	2.9	4.00	595	565
17	4.4	6.84	1,016	958	.4	.57	76	65	4.0	6.27	940	893
18	3.1	5.51	840	775	.5	.90	95	64	2.6	4.61	745	711
19	3.2	6.30	929	874	.6	1.19	133	116	2.6	5.11	796	758
20	2.9	6.25	894	804	.7	1.64	201	157	2.2	4.61	693	647
21	1.9	4.46	694	647	.6	1.48	204	177	1.3	2.98	490	470
22	2.8	7.20	1,088	995	.9	2.25	312	280	1.9	4.95	776	715
23	1.8	4.96	738	653	.7	1.78	247	197	1.1	3.18	491	456
24	2.4	7.41	1,086	956	.6	1.91	304	239	1.8	5.50	782	717
25	1.0	3.37	523	457	.4	1.26	187	155	.6	2.11	336	302
26	1.4	5.10	682	608	.1	.49	78	76	1.3	4.61	604	532
27	.9	3.45	486	408	.5	1.96	245	180	.4	1.49	241	228
28	.9	3.71	591	521	.5	1.08	168	146	.4	2.63	423	375
29	.7	3.48	560	514	.3	.58	65	56	.4	2.90	495	458
30	1.1	5.55	806	697	.2	1.26	132	86	.9	4.29	674	611
31	.3	1.30	121	82	.2	.66	46	23	.1	.64	75	59
32+	1.5	10.31	1,311	1,037	.9	6.59	715	507	.6	3.72	596	530
Total	80.8	121.34	15,625	14,031	16.2	31.35	3,615	2,868	64.6	89.99	12,010	11,163

*Twenty percent of the trees in the initial stand were removed by cutting, 26 percent of the basal area, 23 percent of the gross volume and 20 percent of the net volume.

†Volumes are based on Tables 8-33 in Mesavage, C., and J. W. Girard, 1946. Tables for estimating board-foot volume of timber. U.S.D.A., Forest Service.

order to avoid crossing the control plots which were not to be disturbed. In some cases, this factor also added appreciably to the skidding distance.

Some fuelwood was produced during the operation, but only where it was considered economically feasible in terms of labor costs. In some of the cuttings, especially the shelterwood cuttings, many small trees, with little or no sawlog volume, were cut to accomplish the desired silvicultural results. Many such trees which were too small for logs, and were straight and required very little limbing, were cut into cordwood. Occasional heavy concentrations of slash were lopped after skidding was completed so as to get the slash closer to the ground.

TABLE 5—Average stand data for the four plots treated by the shelterwood method

D. B. H.	Before cutting				Removed in cutting*				After cutting			
	No. of trees per acre	Basal area per acre	Volume per acre†		No. of trees per acre	Basal area per acre	Volume per acre†		No. of trees per acre	Basal area per acre	Volume per acre†	
			Gross	Net			Gross	Net			Gross	Net
in.		sq. ft.	bd. ft.	bd. ft.		sq. ft.	bd. ft.	bd. ft.		sq. ft.	bd. ft.	bd. ft.
8	7.7	3.04	...	...	5.8	2.40	...	...	1.9	.64	...	...
9	7.4	3.17	...	...	5.5	2.38	...	...	1.9	.79	...	...
10	6.6	3.60	232	218	5.0	2.73	176	164	1.6	.87	56	54
11	5.4	3.46	306	287	3.4	2.18	187	172	2.0	1.28	119	115
12	5.8	4.44	432	405	4.4	3.38	327	304	1.4	1.06	105	101
13	5.4	4.94	558	525	4.0	3.67	404	376	1.4	1.27	154	149
14	4.4	4.58	572	531	2.3	2.37	293	265	2.1	2.21	279	266
15	3.2	3.94	523	491	2.1	2.56	329	303	1.1	1.38	194	188
16	3.4	4.69	667	614	2.3	3.14	429	386	1.1	1.55	238	228
17	4.9	7.66	1,149	1,061	3.2	4.89	718	652	1.7	2.77	431	409
18	2.4	4.15	617	465	1.4	2.40	332	195	1.0	1.75	285	270
19	1.9	3.70	589	547	1.0	1.98	309	290	.9	1.72	280	257
20	2.2	4.88	791	740	1.4	3.25	508	469	.8	1.63	283	271
21	2.2	5.45	882	796	1.7	4.25	673	605	.5	1.20	209	191
22	1.9	4.90	854	771	1.3	3.28	568	500	.6	1.62	286	271
23	1.8	5.02	775	670	1.0	2.89	445	371	.8	2.13	330	299
24	2.8	8.65	1,516	1,393	1.8	5.54	912	817	1.0	3.11	604	576
25	2.0	6.76	1,092	987	1.6	5.51	856	764	.4	1.25	236	223
26	1.9	6.86	1,110	979	1.4	5.03	772	668	.5	1.83	338	311
27	1.5	6.02	1,126	1,019	.9	3.52	646	556	.6	2.50	480	463
28	1.0	4.31	790	727	.7	3.27	578	525	.3	1.04	212	202
29	.6	2.79	443	397	.6	2.79	443	397	...	...	...	...
30	.6	3.10	458	383	.5	2.47	334	263	.1	.63	124	120
31	.5	2.66	469	439	.1	.65	115	107	.4	2.01	354	332
32+	1.1	8.02	1,559	1,396	.9	6.41	1,209	1,065	.2	1.61	350	331
Total	78.6	120.79	17,510	15,841	54.3	82.94	11,563	10,214	24.3	37.85	5,947	5,627

*Sixty-nine percent of the trees in the initial stand were removed by cutting, 69 percent of the basal area, 66 percent of the gross volume and 64 percent of the net volume.

†Volumes are based on Tables 8-33 in Mesavage, C., and J. W. Girard, 1946. Tables for estimating board-foot volume of timber. U.S.D.A., Forest Service.

AVERAGE STAND ON THE PLOTS

Data for the average stand on the four plots of each treatment before cutting, the portion removed in cutting, and the residual stand after cutting are presented in Tables 2, 3, 4, and 5. Data for the average stand on the four control plots are listed in Table 6.

Expressed as a percent of the initial stand, the lightest cutting was made in applying the group selection method. Since all trees within a one-tenth-acre group were removed, not all trees within such a group were large, high-volume trees. From an operational standpoint, the group selection method had the advantages of concentrating the activity to one portion of the area, and a natural bunching of the logs

TABLE 6—Average stand data for the four control or uncut plots

D.B.H.	No. of trees per acre	Basal area, per acre	Volume per acre*	
			Gross	Net
in.		sq. ft.	bd. ft.	bd. ft.
8	6.2	2.15	...	...
9	5.3	2.23	...	...
10	5.6	3.02	189	171
11	5.8	3.76	292	269
12	5.9	5.45	480	438
13	5.9	5.34	581	535
14	5.4	5.71	683	611
15	5.1	6.28	850	786
16	3.7	5.20	748	680
17	3.4	5.24	763	694
18	3.1	5.48	796	728
19	2.6	5.12	795	730
20	2.6	5.69	873	781
21	1.8	4.21	680	641
22	2.1	5.56	872	776
23	2.1	6.09	986	893
24	1.0	3.12	404	349
25	1.4	4.64	707	621
26	1.1	4.13	617	528
27	1.9	7.46	1,261	1,084
28	.8	3.19	595	488
29	1.1	5.12	745	620
30	1.3	6.11	1,224	1,080
31	.6	3.29	518	436
32+	1.8	11.50	2,081	1,853
Total	77.6	125.09	17,740	15,792

*Volumes are based on Tables 8-33 in Mesavage, C., and J. W. Girard, 1946. Tables for estimating board-foot volume of timber. U.S.D.A., Forest Service.

for skidding purposes. Much of the resulting slash becomes scattered on areas adjoining the group cutting, which may leave the cutting area in a more favorable condition for the establishment of reproduction.

The heavy cutting of the shelterwood method achieved greater disturbance of the forest floor than the other methods. The occasional heavy concentration of slash hindered the bucking and skidding operations somewhat. This may influence the distribution of subsequent tree reproduction by its blanketing effect on portions of the area.

During the logging operation, records were kept of all trees 8 inches d.b.h. and larger which were broken, pushed over, or otherwise damaged severely so as to require removal. Following completion of logging, a tally was made of the trees less than 8 inches d.b.h. which had been damaged. In this check, damage was considered as being complete destruction of the tree (immediate destruction, or wounding so that death was certain). The logging damage to the stand, by cutting treatment, is listed in Table 7.

All four cutting treatments resulted in considerable damage to trees less than 8 inches d.b.h. Breakage of some of the small trees may not be very serious, since subsequent sprouting will result in some stems with more desirable form than the initial ones. As a percentage of the stand 8 inches d.b.h. and larger, damage by the heavier single tree selection cutting was the highest, and lowest by the group selection cutting.

TABLE 7—Number of trees destroyed by logging damage under each cutting method

D.B.H. inches	Light single tree selection		Heavier single tree selection		Group selection		Shelterwood method	
	No. per acre	Percent of trees in size class	No. per acre	Percent of trees in size class	No. per acre	Percent of trees in size class	No. per acre	Percent of trees in size class
1.....	67.6	23.9	25.2	13.0	30.2	11.7	56.4	36.0
2.....	36.4	25.9	20.1	18.9	26.4	22.4	47.6	41.3
3.....	18.8	24.6	11.3	13.2	26.3	22.5	27.7	31.1
4.....	7.6	16.3	5.1	9.0	6.4	10.0	12.5	18.2
5.....	5.1	23.6	6.3	18.6	5.1	12.7	7.6	33.5
6.....	1.3	7.4	2.6	9.8	1.3	6.8	6.3	26.3
7.....	1.3	10.2	....	....	2.5	16.7	1.3	9.4
8 and up....	1.7	1.9	2.3	3.1	.6	.7	1.4	1.8
Total...	139.8	20.3	72.9	12.3	98.8	13.9	160.8	28.3

SEEDLING TREE REPRODUCTION OBSERVED

Annual observations have been made of the initial establishment and subsequent development of seedling tree reproduction on the area. For this purpose, 16 mil-acre quadrats were located at random within each of the 20 plots. The center of each quadrat was marked permanently with an iron stake. Tallies of the seedling tree reproduction were made at the end of the 1954 and 1955 growing seasons. Estimates of the average number of tree seedlings per acre by species on areas given various cutting treatments are listed in Table 8, and shown graphically for the major species in Figs. 6, 7, 8, 9, and 10.

RELATIONSHIP OF SEEDLINGS TO CUTTING TREATMENT

Although these results are preliminary in nature, several fairly definite relationships of seedling abundance to cutting treatment are already evident. Sugar maple, red maple, and black cherry seedlings are abundant without apparent correlation to intensity of cutting treatment. These species usually produce large crops of seed every year.

TABLE 8—Estimated average number of seedlings per acre, by cutting method, 1954 and 1955

Cutting treatment		Sugar maple	Red maple	Black cherry	Oak	Yellow-poplar	Misc.*	Total
Light single tree selection method	1954	12,015	1,125	1,078	828	516	1,485	17,047
	1955	9,048	4,985	907	1,953	266	1,453	18,612
Heavier single tree selection method	1954	3,844	2,265	2,828	1,156	891	2,063	13,047
	1955	4,031	4,047	4,531	2,250	672	2,689	18,220
Group selection method†	1954	3,188	313	2,563	1,625	1,125	3,873	12,687
	1955	2,188	4,187	2,250	2,188	1,750	1,999	14,562
Shelterwood method	1954	16,171	3,078	1,687	1,781	3,094	2,031	27,842
	1955	12,172	3,322	1,469	2,156	2,470	1,663	23,252
Control—(no cutting)	1954	17,202	359	1,422	688	...	1,109	20,780
	1955	12,374	1,032	1,344	1,953	16	1,359	18,078

*Includes white ash, elm, black walnut, sassafras, basswood, ironwood, and beech.
†Applies only to the area on the plots from which the groups of trees were cut.

The numerous seedlings on the lightly cut and uncut plots are, to a large extent, a temporary annual occurrence. Most of such seedlings do not survive the first growing season. A few may continue growth and development for a year or two before they are eliminated by severe root competition for soil moisture during dry periods, inadequate light, or other causes. Reproduction of these species in the stand was sparse before cuttings were made.

In general, there has been some decrease in the number of sugar maple and black cherry seedlings from the first to the second year. The greatest decrease in sugar maple representation occurred in the uncut plots. The number of red maple seedlings more than doubled for all cutting treatments except the shelterwood areas. The prolific seeding and general aggressiveness of the species are becoming evident.

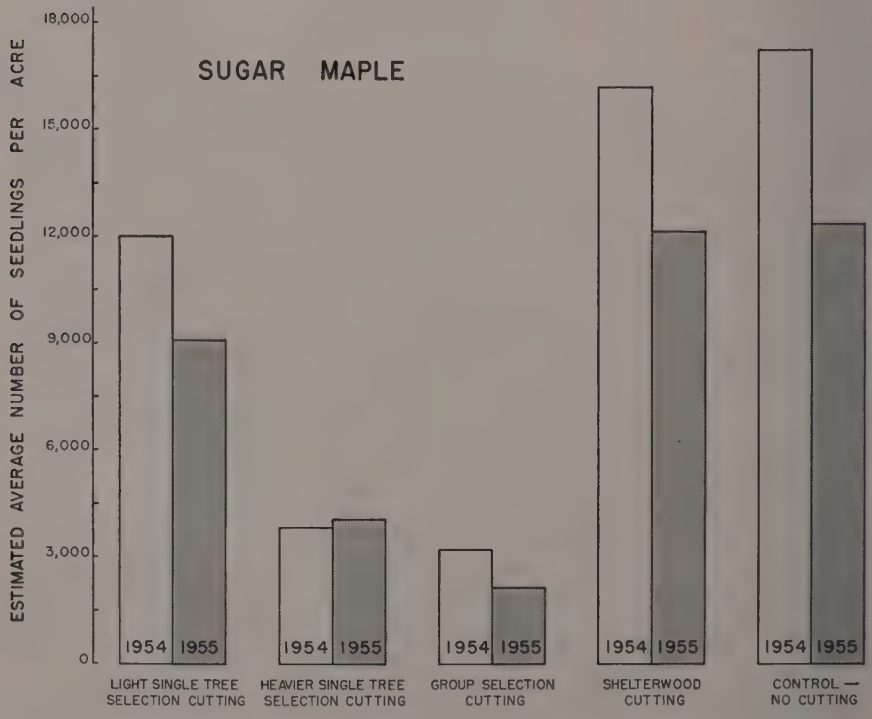

Fig. 6. Estimated average number of sugar maple seedlings per acre, by cutting treatment.

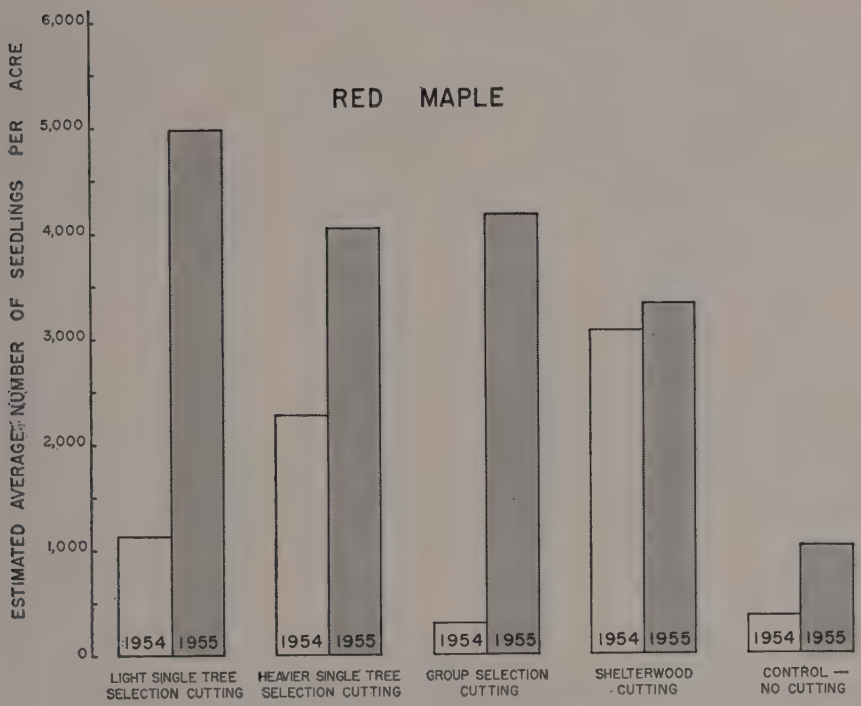

Fig. 7. Estimated average number of red maple seedlings per acre, by cutting method.

The abundance of yellow-poplar seedlings was closely correlated with intensity of cutting. More than six times as many yellow-poplar seedlings were found on the shelterwood areas as on the areas given the light single tree selection cutting. The group selection plots showed an increase in number of seedlings of this species, while a decrease occurred on the single tree selection and shelterwood plots. No yellow-poplar seedlings were found the first year and only an insignificant number the second year on the uncut or control plots.

For oak seedlings, the picture has changed completely from the first to the second year. The acorn crop in the fall of 1953, just prior to cutting, was relatively light. After the first growing season, the abundance of oak seedlings was definitely related to the severity of cutting and disturbance of stand and forest floor conditions. The shelterwood plots showed more than twice as many oak seedlings as the plots given the lightest cutting, and the lowest number was found on the uncut plots.

In the fall of 1954, the acorn crop was very heavy, and by the end of the 1955 growing season, all areas, even the uncut plots, showed large increases in oak seedling numbers. First-year differences in oak seedling populations between cutting treatments were practically erased as all areas reached relative uniformity of stocking. The effect of periodic heavy seed crops on initial seedling abundance is very marked. Future observations will show either continued development, or mortality of these seedlings under the differing conditions on the various cutting plots.

SUMMARY

Initial experimental cuttings were made during the winter of 1953-54 in a relatively undisturbed 40-acre stand of oak and mixed hardwoods in the Fred Russ Forest to determine the suitability of various cutting methods to hardwood stands in southern Michigan.

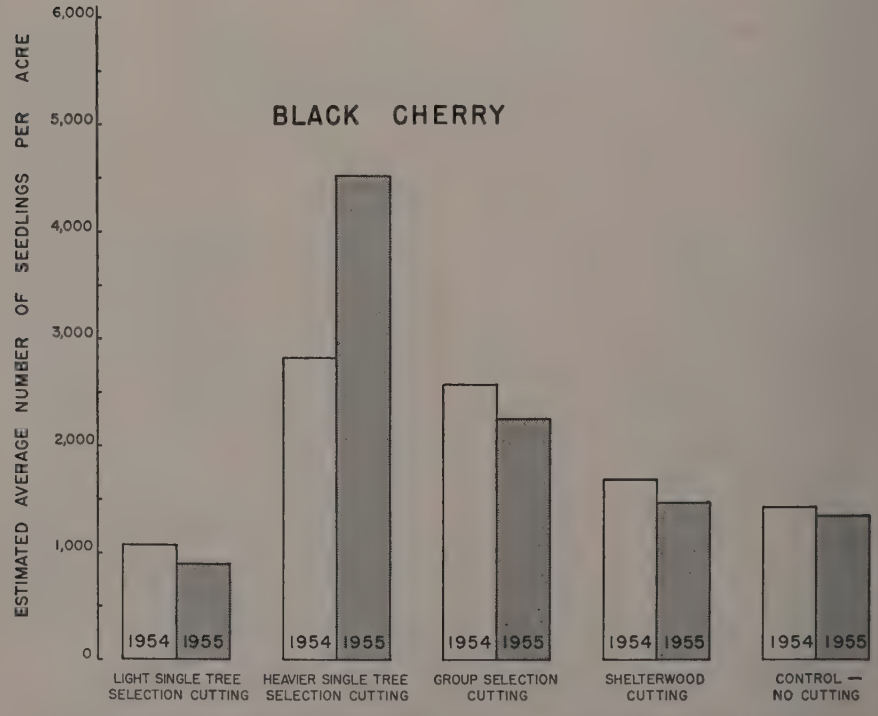

Fig. 8. Estimated average number of black cherry seedlings per acre, by cutting treatment.

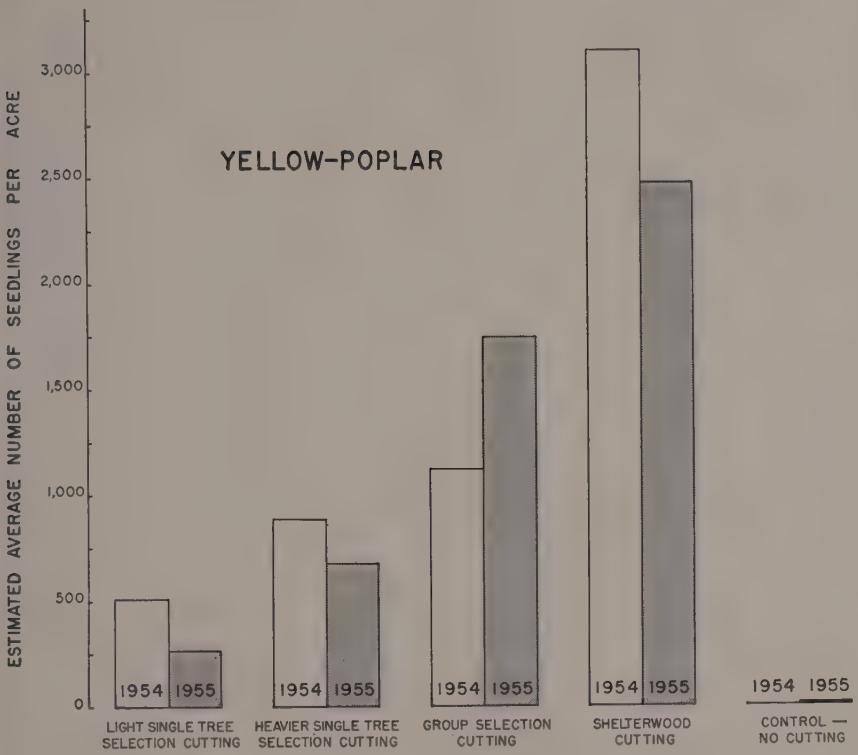

Fig. 9. Estimated average number of yellow-poplar seedlings per acre, by cutting treatment.

Cutting treatments included a light single tree selection method; a heavier single tree selection method; a group selection method; a shelterwood method; and uncut control or check areas. Each treatment was replicated four times.

The average net volume per acre for the stand prior to cutting was 14,800 board feet, and the average basal area per acre was 122 square feet. Residual volumes in board feet and basal areas in square feet per acre after cutting were 10,738 board feet and 88 square feet after the light single tree selection cutting; 8,635 board feet and 74 square feet after the heavier single tree selection cutting; 11,163 board feet and 90 square feet with the group selection cutting; and 5,627 board feet and 38 square feet after the shelterwood cutting.

Logging damage to trees of all sizes was highest under the shelterwood method. Most of the damage was confined to the trees less

than 3 inches in diameter. Lowest damage to trees 8 inches d.b.h. and larger occurred under the group selection method of cutting.

Tallies of reproduction made at the end of the 1954 and 1955 growing seasons showed that sugar maple, red maple, and black cherry seedlings were abundant without apparent relation to method of cutting, or absence of cutting on the control plots. The number of red maple seedlings increased in the second year, while the sugar maple and black cherry showed a decrease.

The representation of yellow-poplar increased directly with severity of cutting, with the shelterwood area having six times as many seedlings as the areas given the lightest cutting. Second-year tallies revealed a decrease in the number of yellow-poplar seedlings.

Oak seedling abundance increased directly with severity of cutting after one growing season. A heavy acorn crop in 1954 resulted in large increases in oak seedlings on all plots to a uniform level of stocking by the end of the second growing season. Future annual observa-

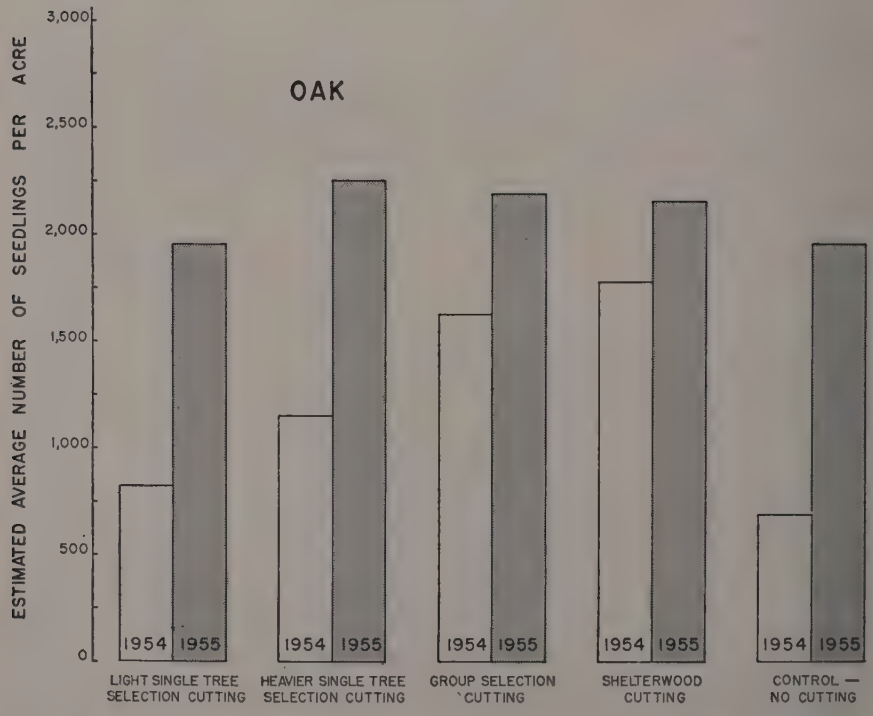

Fig. 10. Estimated average number of oak seedlings per acre, by cutting treatment.

tions will evaluate the reproduction as it either continues to develop or is lost through mortality.

LITERATURE CITED

Goetzen, C. B., W. W. Barton, C. B. Stott, and J. H. Stone (1943). Suggested hardwood tree class standards for farm foresters. U.S.D.A. Forest Service. Region 9, 34 pp.

Rudolph, V. J. (1956). Stand conditions in the old-growth hardwoods of the Fred Russ Forest in southwestern Michigan. Jour. For. 54: 249-254.

U. S. Forest Service (1949). Hardwood log grades for standard lumber. Forest Products Laboratory No. D 1737. Madison, Wisconsin, 61 pp.

Zillgitt, W. M. and S. R. Gevorkiantz (1946). Estimating cull in northern hardwoods. Lake States Forest Expt. Sta. Paper No. 3, 7 pp.

CHANGES IN FARMING, 1945-54 as Shown by Michigan Farm Account Records

By *K. T. WRIGHT*[1]

AGRICULTURAL ECONOMICS DEPARTMENT

FARMERS ARE CONTINUALLY making changes in the organization and operation of their farms, but many people believe that the changes made during the period 1945 through 1954 have been greater than usual in 10 years. Many persons are under the impression that the changes in this decade in prices received for farm products and in prices paid by farmers have been greater than usual, making for exceptionally wide fluctuations in farm income and expenses.

Quite a large number of farmers have been keeping farm records in cooperation with the Agricultural Economics Department, providing information which can be used to study the changes. This article brings together information from the annual reports for the years 1945 through 1954 to show the extent of the physical and financial changes which have occurred.

Information is presented on the farm price situation in the state during this period, the physical and financial changes on all farm account farms, and 10-year averages for each of the areas.

THE PRICE SITUATION

PRICES RECEIVED

The index of prices received by farmers in Michigan, after doubling from 1940 to 1945, averaged 215 percent of 1910-14 for 1945 (Fig. 1). Prices continued rising until 1948, when the index averaged 289.

[1]John C. Doneth supervised the Extension Service project under which these records were collected. L. H. Brown, E. M. Elwood, L. R. Kyle and W. H. Vincent were co-workers. Appreciation also should be expressed to the county agents and cooperating farmers for their contribution in this project which provided the data for this article.

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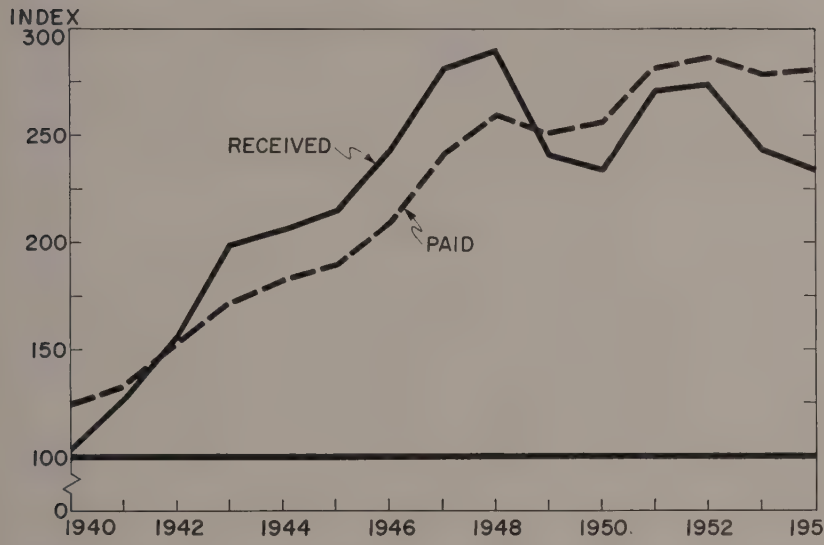

Fig. 1. Indexes of Michigan farm product prices and prices paid by farmers, 1940-54 (1910-14 = 100).

Since then, with the exception of 1951 and 1952, prices have been falling; and in 1954, the price index averaged 233.

Thus, in the decade, there was a range of 74 points in the index, with an average for the period of 252 (compared with 219 for February 1956). The variation in prices received during the decade was somewhat less than in either of the two preceding decades.

PRICES PAID

The index of prices paid by farmers for the items purchased was relatively higher in 1940 than prices received, but rose less rapidly (Fig. 1). Prices paid during 1945 averaged 190 percent of 1910-14, but continued to rise, with the exception of a couple of years, until they reached an index of 287 in 1952.

There was a slight decline from that level in the last two years of the decade. The rise in prices paid in the 10 years was 97 points on the index (approximately 50 percent). This compares with 58 points increase in the previous decade, and 55 points during 1925-34.

The average index of prices paid by farmers during 1945-54 was

253. Thus, while the index of prices paid by farmers averaged the same as received, the trends during the decade were roughly opposite, so that prices paid were above those received at the end of the period by more than they were below in 1945. Prices paid by farmers fluctuate less from year to year than prices received and also decline much slower.

PARITY RATIO

The parity ratio is the percentage that the index of prices received is of prices paid, and indicates when price relationships are favorable or unfavorable, using 1910-14 as the base period.

In 1945, the parity ratio was quite favorable, standing at 113 (Fig. 2). In the first four years of this decade, the parity ratio was above 100, but dropped below in the last six. The average for the 10-year period was 100. This compares with 95 for the preceding decade,

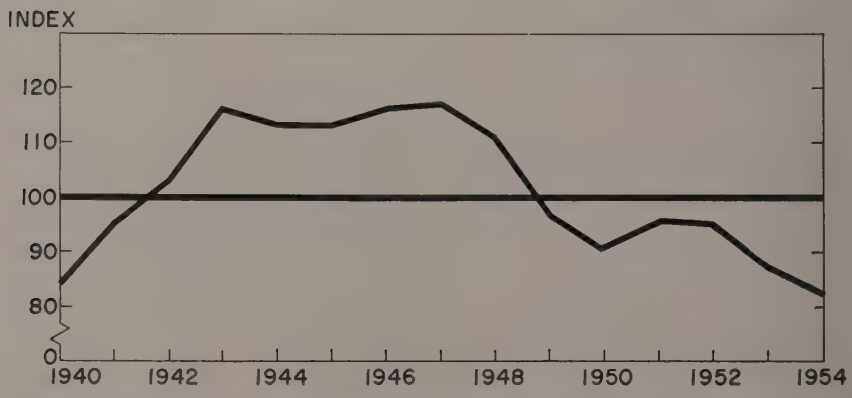

Fig. 2. Parity ratio of Michigan farm product prices, 1940-54 (1910 - 14 = 100).

and 85 for 1925-34. Thus, this 10 years was one of favorable farm price relationships, although the parity ratio in 1954 dropped to 84, which was the lowest it had been since 1940.

CHANGES ON ALL FARMS IN THE PROJECT

Annual reports are published for each type-of-farming area, presenting information from the farm account records kept in conjunc-

tion with this Extension Service project. A summary of the average results of all the areas also is published each year in the Experiment Station Quarterly Bulletin. These annual averages for the 10 years 1945-54 are brought together in this article to indicate the physical and financial changes which have taken place on the farms in this project.

The total number of farms included in the state summaries ranged from 501 to 939 in the various years during this decade. While about 325 of the farmers kept records continuously throughout the period, it should be noted that during the decade many discontinued and many were added.

In other words, the figures presented are the average of all keeping records and not identical farms. It is thought, however, that for most items, the figures give a fairly accurate indication of the trends.

PHYSICAL CHANGES

One of the important changes taking place during 1945-54 has been the increase in the size of farms. The farms in this project are larger than most, averaging 195 acres in 1945 (Table 1). By 1954, the farms of cooperators averaged 230 acres, or an increase of 18 percent. (This was practically the same percentage increase as for all farms in the state, based upon census data). The average acreage of tillable land per farm at the end of this period was 25 percent greater than on the farms included in 1945.

The relative importance of the different crops grown on these farms did not change much. If the average percentage of the tillable acres in the various crops for the first 3 years is compared with the last 3 years of the period, there were increases of 1 to 2 percent in wheat, alfalfa, oats and corn, and a decrease of about 5 percent in miscellaneous crops.

Crop Yields

Crop yields showed a general upward tendency with, of course, considerable year to year variation. Corn showed the most marked increase in yield. A crop yield index, based upon the yields of the 5 crops shown and, using the average yields for the 10 years as 100 percent, was calculated. If the average crop yield index of the first

3 years is compared with the last 3 years of the period, it shows an average annual increase of over 2½ percent a year (the same as for all farms in the state).

Livestock Production

Changes in livestock production on these farms have been more striking than those in crops. For instance, in 1945 there was an average of 26 animal units kept per farm, but in 1954 this had been increased to 37, or an increase of 40 percent (Table 1). It will be recalled that the tillable land per farm was 25 percent greater. A smaller percentage of the farmers had hogs and poultry, and even dairy cows, in 1954 than in 1945; but the average size of the herds and flocks was considerably larger. In other words, there was greater specialization.

Information on the production per cow, hen and sow was not as complete as would be desired to show this change. However, according to the best calculations that could be made, average production per cow was being increased at about 2 percent a year, and egg production per hen slightly faster.

Total Production Per Farm

What about total production per farm in the form of crops, livestock and livestock products? We have seen that the farms were larger, that yields of crops were higher, that more livestock was kept and that livestock was higher producing.

One way of measuring change in total production per farm is to take the gross income and adjust it to a constant price level. On this basis the total production per farm in 1954 was about 65 percent greater than in 1945—32 percent more per tillable acre—a truly startling change.

The labor force to operate the farm averaged 1.7 man-equivalent in 1954 and exactly the same in 1945 (Table 1). This consisted of 12 months by the farm operator, 4 months by his family, and 4 months of hired help. Output or production of farm products per man, therefore, increased the same as the change in output per farm, or an increase of 65 percent. (This, incidentally, was approximately double the increase taking place in industry in the same period.)

FINANCIAL CHANGES

Not only were there changes in the physical organization and production of the farms, but with the price changes already discussed, there were significant changes in the financial side of the farm business. Total investment in the farm increased from $17,538 in 1945 to $37,021 in 1954 (Table 1).

Even this does not show the full amount of the change because the value of many assets—such as the land, buildings and breeding stock—were not increased in the books as prices rose. If investments were adjusted to current market values in 1945 and 1954, it is estimated that the total farm values would be approximately $21,000 and $50,000 respectively.

Gross Income Per Farm

Gross income per farm rose from $7,055 in 1945 to $12,899 in 1954 (Table 1). Livestock and livestock products provided 68 percent of the gross income on these farms during 1945-47, and practically the same during the last three years of the period. (This compares with 63 percent for all farms in the state). Crop sales accounted for about 29 percent of the total during the first three years and 26 percent in the last three, while income from other sources was 3 and 5 percent respectively.

Gross Income Per Tillable Acre

Average gross income per tillable acre in the farm rose from about $54 in 1945 to $83 in 1951, then declined to about $78 in 1954. If the same volume of crops and livestock products had been sold per acre in 1954 as in 1945, the gross income would have been about $59 per tillable acre. The difference between this and the $78 actually received, was due to the one-third greater output per acre.

Farm Operating Expenses

Expenses of operating these farms, exclusive of a charge for the operator's labor and interest on the investment, increased from $3,696 in 1945 to $9,291 in 1954. Of this increase of $5,595, over one-third was due to higher machinery expenses. The increase in direct crop expenses and feed purchases accounted for another one-third. Increases in the other expenses listed in Table 1 made up the remaining third.

Since there was an increase in the size of the farms, the above comparison is a bit misleading. Therefore, expenses per tillable acre operated have been figured (Table 1). Total expenses, including a charge for the operator's labor, averaged about $36 per tillable acre in 1945 and $68 in 1954. This was an increase of 87 percent, or twice the increase in gross income per acre. Prices paid by farmers increased 50 percent, so this means greater physical inputs per acre at the end of the period by these farmers.

Not only was there a sharp increase in expenses during this time, but a marked change in the relative importance of the various items of

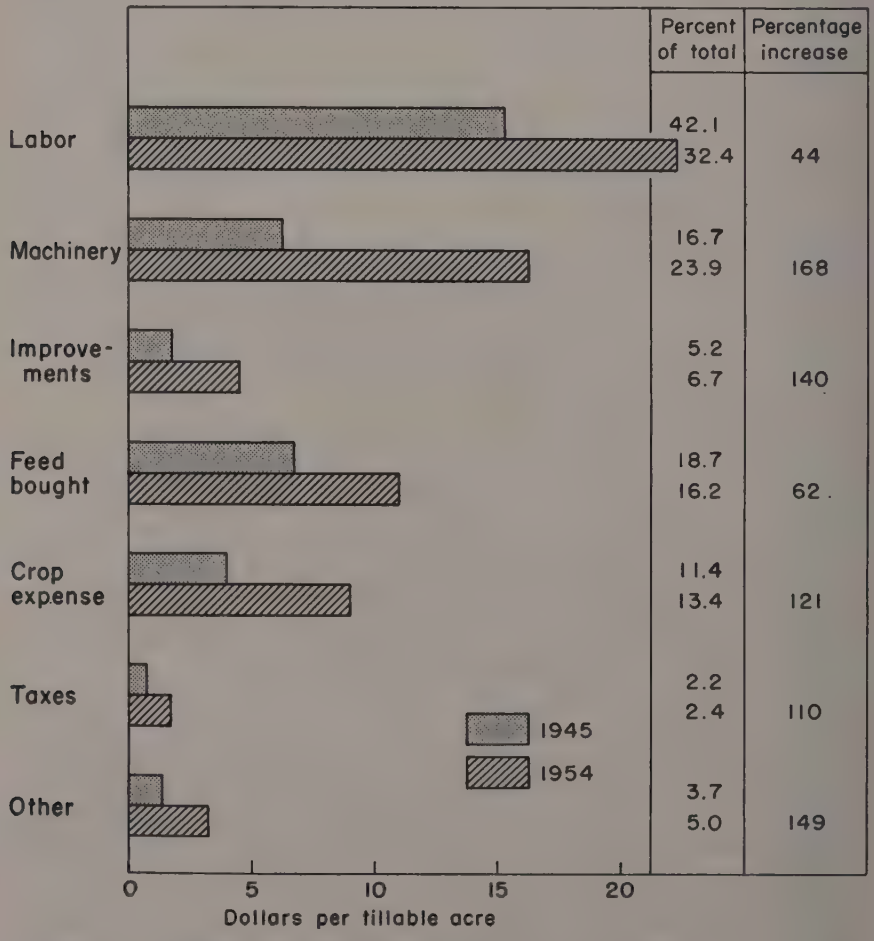

Fig. 3. Expenses per tillable acre on farm account farms have risen and changed in relative importance from 1945-54.

expense (Fig. 3). In 1945, labor—including hired, family and operator—made up 42 percent of the total expense. By 1954, this had declined to 32 percent. On the other hand, the machinery depreciation and operation expense increased from about 17 percent to 24 percent

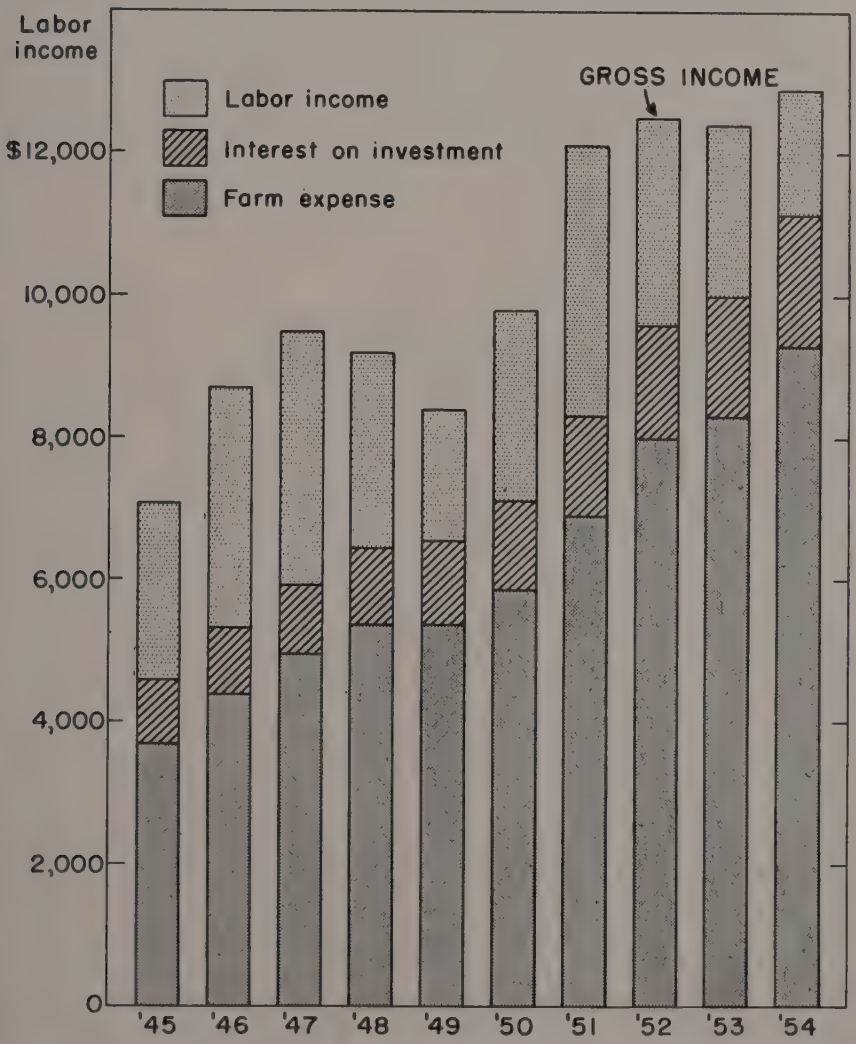

Fig. 4. Farm expenses* have risen steadily while income has fluctuated considerably, resulting in wide variations in labor income.

*Cash operating expense, plus depreciation on buildings and machinery, and the charge for unpaid family labor.

of the total. Feed purchases declined from about 19 to 16 percent. The remaining items all increased slightly in relative importance.

Previously, the increase of about 65 percent in output per man was mentioned, but the sharp increase in machinery expenses has just been pointed out. Thus, the question arises, how does the over-all efficiency of production now compare with that of 1945?

One way to get at this is to calculate the gross income per $100 total expense in operating the farm. This was done, after adjusting both income and expense to 1945 price levels, and it shows that over-all efficiency increased a little over 1 percent a year on these farms during this time.

Net Farm Income

Perhaps the most interesting question is what happened to net farm earnings during this period? We measure net farm earnings by the labor income of the farmer. This is the amount that is left of the gross income after deducting (a) total operating expenses, including depreciation on buildings and machinery, (b) a charge for unpaid family labor, and (c) interest at 5 percent on the farm investment. It is the farmer's return for his labor and management.

In 1945, these farmers had an average labor income of $2,483 (Table 1). In the two following years, it was about $1,000 higher, then declined in the next two, averaging $1,815 in 1949. The next two showed an increase, with the peak of the decade occurring in 1951 with an average of $3,782. Since then, labor incomes have been declining sharply, and the 1954 average was only $1,755. (See Fig. 4 for an annual graphic presentation of gross income, expenses and labor income.)

Over this decade, farm expenses have been steadily rising with gross income varying considerably from year to year. This resulted in wide variations farmers'average net earnings.

TEN-YEAR AVERAGES FOR EACH AREA

The 1945-54 averages for each of the 10 areas, are presented in Table 2. (See Fig. 5 for location of the areas.) This table shows average crop yields, livestock income, gross and net income per farm and per acre, and the like.

It should be pointed out that these figures are from the farmers cooperating in each area and the amount they vary in size, organization and production from the average of all farmers in the area may not be the same. On the other hand, it is probable that the results do indicate, in a general way, the differences in the business of farming in the various areas of the state.

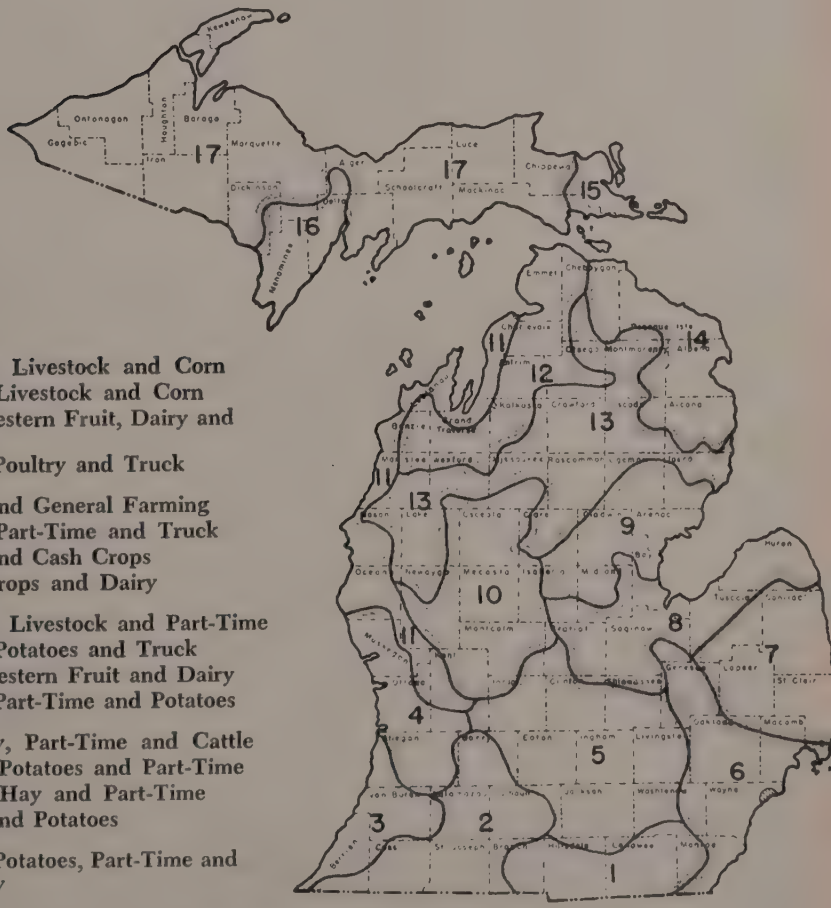
1. General Livestock and Corn
2. Dairy, Livestock and Corn
3. Southwestern Fruit, Dairy and Truck
4. Dairy, Poultry and Truck
5. Dairy and General Farming
6. Dairy, Part-Time and Truck
7. Dairy and Cash Crops
8. Cash Crops and Dairy
9. General Livestock and Part-Time
10. Dairy, Potatoes and Truck
11. Northwestern Fruit and Dairy
12. Dairy, Part-Time and Potatoes
13. Forestry, Part-Time and Cattle
14. Cattle, Potatoes and Part-Time
15. Cattle, Hay and Part-Time
16. Dairy and Potatoes
17. Dairy, Potatoes, Part-Time and Forestry

Fig. 5. Type of Farming Areas in Michigan.

TABLE 1—All account farms in Michigan: financial summary, crop and livestock production, and expenses, 1940, 1945-54

Item	1940	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954
Number of farms	1,263	939	838	830	846	912	826	685	551	501	545
SIZE OF BUSINESS											
Total acres per farm	170	195	195	193	196	198	201	210	223	224	230
Tillable acres	112	131	133	134	136	136	138	146	156	160	166
Total work units*	452	490	498	473	466	477	493	529	562	593	597
FARM INVESTMENT†											
Real estate (less house)	$9,145	$10,469	$11,056	$12,048	$11,912	$12,567	$13,369	$14,264	$15,874	$16,690	$19,603
Machinery and equipment	1,574	2,590	2,872	3,315	3,876	4,758	5,264	6,090	7,118	7,461	7,880
Livestock	1,843	2,572	2,685	3,220	3,147	3,539	3,859	4,579	5,595	5,456	5,531
Feed and crops	1,076	1,907	2,015	2,414	2,633	2,482	2,649	3,030	3,642	3,778	4,007
Total	13,638	17,538	18,628	20,997	21,568	23,346	25,141	27,963	32,229	33,385	37,021
Machinery investment per tillable acre*	$ 14.05	$ 19.77	$ 21.59	$ 24.74	$ 28.50	$ 34.99	$ 38.14	$ 41.71	$ 45.63	$ 46.63	$ 47.47
FARM INCOME											
Livestock	$ 2,051	$ 4,893	$ 5,856	$6,418	$ 6,534	$ 5,897	$ 7,009	$ 8,952	$ 9,118	$ 8,688	$ 8,558
Crops	891	1,948	2,641	2,663	2,223	2,085	2,372	2,646	2,872	3,143	3,643
Other	168	214	221	351	415	387	422	497	526	614	698
Gross income	3,110	7,055	8,718	9,432	9,172	8,369	9,803	12,095	12,516	12,445	12,899
Gross income per tillable acre	$ 27.65	$ 54.37	$ 65.39	$ 70.30	$ 67.44	$ 61.59	$ 70.91	$ 83.10	$ 80.22	$ 78.00	$ 77.52
FINANCIAL SUMMARY											
Gross income	$ 3,110	$ 7,055	$ 8,718	$ 9,432	$ 9,172	$ 8,369	$ 9,803	$12,095	$12,516	$12,445	$ 12,899
Total farm expense‡	1,641	3,696	4,413	4,958	5,358	5,386	5,867	6,916	7,979	8,326	9,291
Net farm income	1,469	3,359	4,305	4,474	3,814	2,983	3,936	5,179	4,537	4,119	3,608
Interest on investment @5%	682	876	931	988	1,079	1,168	1,248	1,397	1,611	1,672	1,853
Labor income	$ 787	$ 2,483	$ 3,374	$ 3,486	$ 2,735	$ 1,815	$ 2,688	$ 3,782	$ 2,926	$ 2,447	$ 1,755

CROP ACREAGES AND YIELDS, 1945-54 (ALL FARM ACCOUNT FARMS)

PERCENT OF TILLABLE ACRES IN:											
Tillable pasture	18	17	19	17	16	17	17	17	17	18	17
Hay: Alfalfa	16	12	11	11	11	12	13	17	12	12	14
Other	11	14	14	16	15	14	14	11	15	16	13
Corn (grain and silage)	15	17	18	17	16	17	16	17	17	18	20
Wheat	7	9	8	12	13	12	10	11	12	13	9
Oats (oats and barley mixture)	11	14	15	10	14	15	14	14	16	13	14
Others	22	17	15	17	15	13	16	13	11	10	13
CROP YIELDS											
Hay: Alfalfa	1.9	2.0	1.6	1.8	1.9	1.9	2.1	2.1	2.2	2.2	2.6
Other	1.6	1.6	1.3	1.4	1.4	1.3	1.4	1.7	1.7	1.7	2.0
Corn, shelled	36	42	32	30	44	54	46	51	58	56	58
Wheat	26	30	28	27	26	28	27	29	28	32	32
Oats	50	43	50	37	41	38	42	44	37	40	44
Crop yield index (1945-54 av. =100)	95	98	93	83	94	96	97	106	105	108	119

*Fruit farms not included.
†Are long-time book values and not current value.
‡Includes cash operating expense, depreciation and family labor, but not operator's labor.

LIVESTOCK NUMBERS, PRODUCTION AND INCOME, 1945-54* (ALL FARM ACCOUNT FARMS)

LIVESTOCK*											
Productive animal units*	24.0	26.5	27.8	27.1	23.9	25.6	31.7	31.6	36.3	36.4	37.5
Tillable acres per P.A.U.*	4.6	4.9	4.8	5.0	5.7	5.3	4.5	4.6	4.2	4.3	4.6
CATTLE—% reporting dairy	....	....	99	99	98	97	95	97	98	93	91
Cows per farm	10.2	12.3	12.8	12.5	12.2	12.6	13.6	14.1	15.4	17.3	18.1
Dairy produce sales per cow	$ 102	$ 226	$ 267	$ 282	$ 297	$ 266	$ 265	$ 335	$ 360	$ 327	$ 302
Dairy produce sales per farm	1,039	2,782	3,496	3,507	3,848	3,362	3,604	4,726	5,541	5,676	5,477
Cattle income	418	727	890	1,098	1,240	1,123	1,466	2,236	1,707	2,734	4,183
HOGS—% reporting	....	....	72	66	61	60	59	58	54	45	41
Sows per farm	1.5	1.5	3.2	2.1	3.1	2.8	3.2	3.4	3.5	3.3	4.1
Litters per farm	2.5	2.5	5.6	3.6	5.4	4.7	5.2	6.0	6.0	6.1	7.4
Pigs per litter	6.5	6.5	6.5	6.4	6.8	6.6	6.6	6.7	6.9	6.8	7.2
Hog income per litter	$ 83	$ 215	$ 184	$ 399	$ 218	$ 227	$ 260	$ 297	$ 297	$ 381	$ 343
Income per farm	207	538	1,032	1,435	1,181	1,075	1,476	1,776	1,778	2,310	2,542
SHEEP—% reporting	...	...	19	15	14	12	11	13	12	12	21
Ewes per farm	10	6	38	39	41	38	42	37	44	46	30
Lambs per 100 ewes	95	96	100	98	99	92	97	99	92	98	95
Income per ewe	$ 11	$ 17	$ 19	$ 21	$ 18	$ 24	$ 32	$ 39	$ 18	$ 21	$ 21
Income per farm	117	102	717	814	722	902	1,371	1,453	789	975	628
POULTRY—% reporting	...	...	81	80	74	74	69	70	67	63	64
Hens per farm	98	106	133	130	127	135	155	154	169	188	182
Egg sales per hen	$ 2.10	$ 4.86	$ 4.62	$ 6.03	$ 6.50	$ 5.94	$ 5.40	$ 6.75	$ 6.26	$ 6.53	$ 5.79
Egg sales per farm	205	515	670	783	918	801	834	1,040	1,123	1,243	1,051
Meat income per farm	64	229	265	227	299	253	343	374	359	562	423

FARM EXPENSES—TOTAL PER FARM AND PER TILLABLE ACRE, 1945-54 (ALL FARM ACCOUNT FARMS)

FARM EXPENSES											
Hired labor	$ 270	$ 557	$ 767	$ 634	$ 665	$ 628	$ 684	$ 739	$ 888	$ 929	$ 1,011
Family labor	220	386	418	468	509	469	449	487	467	485	619
Machinery	344	793	922	1,162	1,365	1,497	1,658	1,939	2,253	2,445	2,707
Improvements	141	247	317	349	373	422	454	526	617	667	764
Feed bought	278	889	921	1,231	1,190	1,062	1,192	1,502	1,726	1,634	1,832
Crop expense	212	544	741	770	863	877	918	1,111	1,303	1,395	1,523
Taxes	78	103	118	128	138	146	168	185	223	241	273
Other	98	177	209	216	255	285	344	427	502	530	562
Total	1,641	3,696	4,413	4,958	5,358	5,386	5,867	6,916	7,979	8,326	9,291
Operator's labor	532	1,060	1,067	1,407	1,418	1,418	1,431	1,433	1,427	1,430	2,044
Total expense	2,173	4,756	5,480	6,365	6,776	6,804	7,298	8,349	9,406	9,756	11,335
EXPENSES PER TILLABLE ACRE											
Labor (hired, family and operator)	$ 9.08	$ 15.33	$ 16.89	$ 18.70	$ 19.06	$ 18.51	$ 18.55	$ 18.27	$ 17.83	$ 17.78	$ 22.08
Machinery	3.06	6.08	6.92	8.66	10.04	11.02	11.99	13.32	14.44	15.28	16.27
Improvements	1.25	1.91	2.38	2.60	2.74	3.10	3.28	3.62	3.95	4.17	4.59
Feed bought	2.47	6.80	6.91	9.17	8.75	7.81	8.63	10.32	11.07	10.22	11.01
Crop expense	1.88	4.14	5.56	5.74	6.34	6.45	6.65	7.63	8.35	8.72	9.15
Taxes	.70	.78	.88	.96	1.01	1.08	1.21	1.27	1.43	1.51	1.64
Other	.88	1.36	1.56	1.61	1.89	2.10	2.85	2.93	3.21	3.32	3.39
Total	$ 19.32	$ 36.40	$ 41.10	$ 47.44	$ 49.83	$ 50.07	$ 53.16	$ 57.36	$ 60.28	$ 61.00	$ 68.13
MAN LABOR											
Number of men	1.9	1.7	1.8	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.7
Work units per man	242	286	284	286	281	292	303	319	306	360	358
Gross income per man	$ 1,637	$ 4,150	$ 4,843	$ 5,548	$ 5,395	$ 4,939	$ 5,810	$ 7,066	$ 7,177	$ 7,243	$ 7,463

*Information by kinds is on the basis of farms reporting, except in 1940 and 1945.

TABLE 2—1945-54 averages by areas: financial summary, crop and livestock production, and expenses

Item	All farm account farms	Type-of-farming areas									
		1	2	3 and 11	4	5	6 and 7	8	9, 12 and 14	10	15, 16 and 17
Number of farms	747	85	63	41	39	143	62	67	106	53	88
SIZE OF BUSINESS											
Total acres per farm	207	198	228	152	164	246	222	169	231	214	195
Tillable acres	144	155	182	111	125	184	176	130	124	133	101
Total work units	518	566	598	...	550	635	586	516	411	483	391
FARM INVESTMENT*											
Real estate (less house)	$13,785	$15,422	$15,118	$19,788	$11,552	$18,072	$16,822	$16,564	$ 8,952	$10,141	$ 7,161
Machinery and equipment	5,122	5,351	5,348	5,741	5,115	6,085	5,804	5,505	3,947	4,653	3,763
Livestock	4,018	5,069	4,831	2,558	3,689	5,502	4,705	3,650	3,106	3,310	2,511
Feed and crops	2,856	4,008	3,455	2,185	2,797	4,024	3,044	3,369	1,589	1,944	1,107
Total	24,028	29,850	28,752	30,272	23,151	33,684	30,373	29,089	17,234	20,047	14,542
Machinery investment per tillable acre	$34.92	$34.14	$28.90	$51.08	$41.01	$34.99	$33.76	$42.25	$30.98	$34.57	$36.36
FARM INCOME											
Livestock	$ 8,192	$ 8,715	$ 9,142	$ 3,265	$ 9,049	$ 9,304	$ 8,273	$ 7,314	$ 4,832	$ 6,338	$ 4,918
Crops	2,624	2,773	2,592	11,229	1,315	2,566	2,399	3,980	1,150	1,621	743
Other	435	420	520	597	337	491	379	479	353	407	429
Gross income	10,250	11,907	12,259	15,091	10,702	12,362	11,051	11,773	6,335	8,367	6,090
Gross income per tillable acre	$ 70.88	$ 76.83	$ 66.88	$134.05	$ 85.80	$ 71.93	$ 62.66	$ 90.94	$ 50.38	$ 62.94	$ 63.46
FINANCIAL SUMMARY											
Gross income	$10,250	$11,907	$12,259	$15,091	$10,703	$12,362	$11,051	$11,773	$ 6,335	$ 8,367	$ 6,090
Total farm expense†	6,219	6,847	7,886	10,442	6,875	7,099	6,955	6,466	3,845	5,199	3,727
Net farm income	4,031	5,060	4,372	4,649	3,827	5,263	4,096	5,307	2,490	3,168	2,363
Interest on investment @ 5%	1,282	1,494	1,435	1,513	1,154	1,683	1,516	1,538	862	1,000	726
Labor income	$ 2,743	$ 3,567	$ 2,938	$ 3,136	$ 2,673	$ 3,579	$ 2,548	$ 3,769	$ 1,627	$ 2,166	$ 1,637

TEN-YEAR AVERAGES (1945-54), BY AREAS, OF FARM ACCOUNT FARMS, MICHIGAN (CROP ACREAGES AND YIELDS)

PERCENT OF TILLABLE ACRES IN:										
Tillable pasture	17	12	19	11	15	16	21	12	22	20	17
Hay: Alfalfa	13	12	12	9	10	12	13	12	15	15	9
Other	14	10	11	8	13	10	14	7	19	17	40
Corn (grain and silage)	17	28	21	10	21	21	13	18	10	14	4
Wheat	10	15	15	4	15	14	10	12	5	7	2
Oats (oats and barley mixture)	14	16	14	7	18	14	14	16	13	13	17
Others	15	8	9	4	8	10	15	22	15	14	13
CROP YIELDS											
Hay: Alfalfa	2.0	2.1	1.9	1.9	2.2	2.2	2.1	2.0	1.7	2.0	1.9
Other	1.6	1.6	1.5	1.6	1.7	1.7	1.8	1.8	1.5	1.5	1.5
Corn, shelled	47	51	37	46	47	47	46	53	33	40	...
Wheat	29	30	27	32	27	28	29	33	25	28	18
Oats	42	43	38	39	43	43	43	49	36	36	39
Crop yield index (av. of all = 100)	100	105	93	80	102	102	99	114	90	92	99

*Are long-time book values and not current values.
†Includes cash operating expense, depreciation and family labor, but not operator's labor.

NINE-YEAR AVERAGES (1946-54), BY AREAS, OF FARM ACCOUNT FARMS, MICHIGAN
(LIVESTOCK NUMBERS, PRODUCTION AND INCOME)*

LIVESTOCK*											
Productive animal units	30.9	37.3	40	12.9	29.6	37.63	32.7	28.6	26.2	27.9	22.4
Tillable acres per P.A.U.	4.8	4.2	4.6	5.2	4.2	6.06	5.5	4.6	4.9	4.9	4.9
CATTLE—% reporting dairy	96	94	98	78	98	97	87	98	99	99	99
Cows per farm reporting	14.3	13.0	15.5	8.6	14.3	14.4	18.3	13.2	12.3	14.3	14.4
Dairy prod. sales per cow	$ 305	$ 325	$ 306	$ 291	$ 305	$ 373	$ 339	$ 333	$ 235	$ 280	$ 261
Dairy prod. sales per farm	4,360	4,228	4,744	2,500	4,360	5,376	6,206	4,398	2,888	4,001	3,759
Cattle income per farm	1,853	2,060	1,408	933	1,348	1,512	1,759	1,424	1,335	1,296	787
HOGS—% reporting	57	79	70	...	48	54	27	63	68	49	33
Sows per farm	3.2	4.7	5.5	...	2.0	4.2	2.1	2.6	1.6	1.6	1.1
Litters per farm	5.6	8.7	10.1	...	3.3	7.7	3.7	4.3	2.3	2.6	1.3
Pigs per litter	6.7	6.5	6.7	...	6.8	6.6	7.8	7.2	7.2	7.4	5.5
Income per farm	$ 1,623	$ 2,583	$ 3,158	...	$ 972	$ 2,133	$ 1,014	$ 1,439	$ 562	$ 768	$ 115
SHEEP—% reporting	14	18	22	...	.8	24	10	9	14	2	5
Ewes per farm	39	31	48	...	9	50	30	27	42	11	15
Lambs per 100 ewes	97	88	99	...	32	97	83	99	98	30	65
Sheep and wool income per ewe	$ 24	$ 26	$ 20	...	$ 19	$ 23	$ 23	$ 28	$ 19	$ 16	$ 19
Income per farm	930	794	980	...	172	1,166	694	746	806	171	279
POULTRY—% reporting	71	79	67	63	92	75	71	68	71	61	63
Hens per farm	153	188	176	166	390	141	114	130	68	154	100
Egg sales per hen	$ 6.14	$ 6.07	$ 6.51	$ 5.89	$ 7.28	$ 5.99	$ 5.91	$ 4.96	$ 5.24	$ 6.38	$ 6.63
Egg sales per farm	940	1,141	1,145	978	2,839	844	674	645	356	982	663
Meat income per farm	345	306	377	181	626	600	332	249	179	301	92

TEN-YEAR AVERAGES (1945-54), BY AREAS, OF FARM ACCOUNT FARMS, MICHIGAN
(FARM EXPENSES—TOTAL PER FARM AND PER TILLABLE ACRE)

FARM EXPENSES											
Hired labor	$ 750	$ 536	$ 810	$ 3,272	$ 774	$ 660	$ 992	$ 625	$ 330	$ 579	$ 426
Family labor	476	492	488	450	430	491	622	559	453	445	370
Machinery	1,674	1,800	1,924	2,137	1,446	1,950	1,927	1,866	1,216	1,476	1,088
Improvements	474	544	576	5,658	407	616	547	538	285	350	255
Feed bought	1,318	1,808	2,131	928	2,473	1,478	1,148	1,142	637	1,088	868
Crop expense	1,005	1,107	1,308	2,394	804	1,095	1,052	1,023	603	849	444
Taxes	172	216	219	181	173	228	210	194	91	113	71
Other	351	344	431	513	368	412	459	358	230	299	205
Total	6,219	6,847	7,886	10,441	6,875	6,922	6,955	6,305	3,845	5,199	3,727
Operator's labor	1,414	1,480	1,496	1,421	1,487	1,493	1,454	1,468	1,259	1,408	1,232
Total	$ 7,633	$ 8,327	$ 9,383	$11,863	$ 8,362	$ 8,355	$ 8,409	$ 7,773	$ 5,104	$ 6,606	$ 4,959
EXPENSES PER TILLABLE ACRE											
Labor (hired, fam. and oper.)	$ 18.30	$ 16.07	$ 15.27	$ 46.09	$ 21.59	$ 15.23	$ 17.23	$ 20.39	$ 16.64	$ 18.31	$ 21.28
Machinery	11.40	11.50	10.38	18.74	11.60	11.11	10.78	14.29	9.58	10.98	11.00
Improvements	3.23	3.48	3.12	4.99	3.26	3.52	3.06	4.12	2.27	2.61	2.62
Feed bought	9.70	11.61	11.58	8.44	19.84	8.51	6.49	8.77	5.12	8.21	9.15
Crop expense	6.87	7.08	7.08	21.41	6.44	6.27	6.14	7.80	4.76	6.18	4.55
Taxes	1.18	1.38	1.19	1.62	1.39	1.31	1.17	1.49	.72	1.00	.72
Other	2.42	2.19	2.33	4.55	2.95	2.39	2.52	2.74	1.80	2.22	2.11
Total	$ 52.48	$ 53.40	$ 50.94	$105.83	$ 67.06	$ 48.33	$ 47.39	$ 60.09	$ 40.89	$ 49.51	$ 51.43
MAN LABOR											
Number of men	1.7	1.6	1.7	2.7	1.7	1.7	1.9	1.7	1.6	1.6	1.5
Works units per man	304	349	342	...	323	347	309	301	266	296	256
Gross income per man	$ 5,963	$ 7,386	$ 6,999	$ 5,371	$ 6,245	$ 7,047	$ 5,835	$ 6,693	$ 4,004	$ 5,180	$ 3,983

*Information by kinds is on the basis of farms reporting.

FIELD STUDIES ON THE ESTABLISHMENT OF MERION BLUEGRASS IN VARIOUS SEED MIXTURES

By F. V. JUSKA,[1] J. TYSON[2] and C. M. HARRISON[3]

A PREVIOUS REPORT of a greenhouse experiment (Juska et al., 1955) reported the competitive effects of redtop, creeping red fescue and domestic ryegrass when sown in mixtures with Merion bluegrass.

As part of that study, field plots were seeded with mixtures and treated as in the greenhouse experiment. The results reported herein are from these field plots and are a continuation of the greenhouse work.

REVIEW OF LITERATURE

Comparatively few field studies have been made on the competitive nature of grasses used in mixtures for turf purposes, but several workers have investigated the effects of heights and frequencies of cutting and of levels of nitrogen fertilization on the production of top and root growth.

Graber (1929) found that the production of root, rhizome and top growth of bluegrass, fescue and timothy was correlated with height of cutting. The total top weight not only varied inversely with height of cutting, but a reduction of growth occurred for several months after severe defoliation. He also found that, after frequent removal of the photosynthetic surface, nitrogen often became the first factor to limit growth.

Mortimer and Ahlgren (1936) found that nitrogen and water were the two most important factors limiting the growth of grass. Working with bluegrass, redtop, ryegrass and fescue, Carroll (1943) noted

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that plots treated with high nitrogen were less able to withstand drought than the same species with low nitrogen.

Tyson (1954) found that twice-a-week clipping of Merion bluegrass at three-quarters of an inch had no apparent detrimental effect on the turf. Comparison was made with the same frequency of clipping at 1½ inches. Harrison and Hodgson (1939) obtained a larger current foliage production of grasses from frequent and close defoliation than from less defoliation with the same frequency, but found that a decline in productivity occurred later under the former treatment.

EXPERIMENTAL PROCEDURE

An area on the University Farm at East Lansing, Michigan, was selected for this experiment. The soil is a slightly acid Conover loam, pH 6.5, of medium fertility. This field had been a clover-brome-grass hayfield for several years prior to seeding. The plot area was plowed in the spring of 1953, fallowed during the summer, and then harrowed, leveled, and cultipacked in August.

A variety of Kentucky bluegrass, Merion bluegrass *(Poa pratensis)* creeping red fescue *(Festuca rubra, var genuina)* redtop *(Agrostis alba),* and domestic ryegrass *(Lolium multiflorum* and *perenme)* were seeded singly and in 16 mixtures (Table 1). *The seeds for each mixture were calculated on a percentage basis by weight and were seeded at the rate of 1 pound of the resulting mixture for each 1,000 square feet of area.*

The total area, 80 by 100 feet, was divided into 20 plots, each 10 by 40 feet in dimension. Each plot was seeded to one of the four species or one of the mixtures. The seed for each plot was sown by hand on September 7, 1953. One half of each 10-by 40-foot plot was maintained at a high level of nitrogen and the other half at a low level during the course of the experiment.

The high nitrogen subplots received a broadcast application of 10 pounds of 10-10-10 fertilizer plus 10 pounds of ammonium sulfate per 1,000 square feet of area prior to seeding in August 1953. Ten pounds of ammonium sulfate per 1,000 square feet of area were broadcast on March 24, 1954; 30 pounds of activated sewage sludge, 6-4-0 analysis, on June 5, 1954; and 5 pounds of ammonium sulfate on September 8, 1954.

The low nitrogen treatments consisted of the initial broadcast application of 10 pounds of 10-10-10 fertilizer per 1,000 square feet,

and 15 pounds of activated sewage sludge on March 24, 1954, with no additional fertilizer in June and September.

The grasses were quite well established by early spring although some heaving had occurred. At that time, the plots were again split to form 10-by 10-foot areas. One of each pair was thereafter mowed at a height of three-quarters of an inch, or "low cut;" the other was mowed at a height of 1½ inch, or "high cut". Mowing was started on April 19, 1954. The plots were mowed at weekly intervals until May 26 and then twice weekly until August 1, after which they were mowed weekly until the last cutting of the year on October 24.

An observational technique was used for making the botanical analyses of the grasses and weeds in the turf on the different plots. The estimations were made on individual 1-square foot areas taken at random at four different places on each plot. The four readings were averaged. Estimates were made on April 22, June 22, and October 26. The last estimations were made independently by two observers and the averages were recorded.

EXPERIMENTAL RESULTS

The seeds of the individual species varied in length of time required for germination. Those of redtop and domestic ryegrass were first to germinate, followed in order by those of creeping red fescue

Fig. 1. The comparative growth of the four species approximately 7 weeks after seeding. 1. Merion bluegrass, 2. Creeping red fescue, 3. Redtop, 4. Domestic ryegrass. (Photographed October 23, 1953)

and Merion bluegrass. The two fastest germinating species made the most rapid initial growth and soon dominated the turf of the plots in which they were planted. Both of them produced a heavy growth within 6 weeks after seeding. The turf produced by redtop was dense, fine-textured and short, but the ryegrass turf was coarse and open textured.

The turf on the red fescue and Merion bluegrass plots was slow to become established and formed a sparse ground cover during the fall season. The spring application of nitrogen stimulated the growth of the creeping red fescue and Merion bluegrass so they began to compete on a more favorable basis with the ryegrass and redtop.

The high nitrogen treatment caused these grasses, especially the Merion bluegrass, to spread so rapidly that by April 19, 1954, when mowing was initiated, they had produced dense, medium-textured turfs.

Mowing all of the species at the designated heights aided the slower growing grasses, Merion bluegrass and creeping red fescue, in their competitive relationship with redtop and ryegrass. Mowing at either height, ¾ or 1½ inches, was so harmful to the domestic ryegrass that it almost disappeared from the plots by the fall of 1954, leaving open spaces in which weeds appeared.

The turf produced in plots in which domestic ryegrass seed was included in the mixtures was less desirable from an appearance standpoint than the others, with the least desirable being that produced on the plot seeded with the mixture of 90 percent Merion bluegrass and only 10 percent ryegrass. The proportion of ryegrass plants to bluegrass plants in this plot was approximately one to nine.

This sparse population of coarse, tall-growing ryegrass plants amid the dense, shorter-growing Merion bluegrass produced a turf with mixtures of colors, textures, and variable heights which was very unsightly.

The mixing of domestic ryegrass, redtop and/or creeping red fescue with Merion bluegrass, a common practice in the seed trade, interfered in every case with the establishment of the Merion bluegrass turf (as may be seen in Tables 1 and 2). Table 2 is a summary of the readings made in October of 1954, 1 year after planting.

Percentage of Merion bluegrass in the turf on plots in which mixtures of grasses were sown was influenced both by the amount of Merion bluegrass and numbers of seeds of competitive grasses seeded

TABLE 1—Percentages of Merion bluegrass in field plots as determined by observational analysis on three different dates

Mixtures (percent by weight)	High nitrogen treatment						Low nitrogen treatment					
	1½-inch cut			¾-inch cut			¾-inch cut			1½-inch cut		
	April	June	Oct.*	April	June	Oct.*	April	June	Oct. *	April	June	Oct.*
1. Merion bluegrass, 100	..	..	..	..	..	..	..	..	..	..	..	..
2. Creeping red fescue, 100	..	..	..	..	..	..	..	..	..	..	..	..
3. Redtop, 100	..	..	..	..	..	..	..	..	..	..	..	..
4. Domestic ryegrass, 100	..	..	..	..	..	..	..	..	..	..	..	..
5. Bluegrass, 90; fescue, 10	88	92	95	95	97	93	89	93	83	91	85	83
6. Bluegrass, 70; fescue, 30	30	64	85	63	50	85	48	30	58	66	40	45
7. Bluegrass, 50; fescue, 50	58	15	73	44	20	78	40	5	35	43	10	25
8. Bluegrass, 30; fescue, 70	39	10	65	27	15	73	27	5	25	27	5	8
9. Bluegrass, 10; fescue, 90	16	2	20	8	3	38	6	1	10	12	1	3
10. Bluegrass, 90; redtop, 10	81	85	95	90	85	90	81	80	80	85	75	70
11. Bluegrass, 90; ryegrass, 10	93	90	96	94	95	98	92	85	99	92	80	99
12. Bluegrass, 70; redtop, 30	50	40	25	51	50	50	49	30	28	36	20	18
13. Bluegrass, 70; ryegrass, 30	70	85	93	73	85	93	67	80	91	80	75	86
14. Bluegrass, 50; redtop, 50	31	25	45	17	20	43	13	5	33	14	5	25
15. Bluegrass, 50; ryegrass, 50	55	60	85	42	80	85	69	70	80	60	50	75
16. Bluegrass, 50; fescue, 30; redtop, 10; ryegrass, 10	43	45	30	46	47	38	34	45	33	33	29	28
17. Bluegrass, 30; fescue, 30; redtop, 20; ryegrass, 20	23	34	30	28	40	20	23	28	20	20	32	18
18. Bluegrass, 30; fescue, 50; redtop, 10; ryegrass, 10	25	17	32	28	35	36	29	22	22	21	24	10
19. Bluegrass, 70; fescue, 10; redtop, 10; ryegrass, 10	66	63	73	67	65	72	64	69	63	60	62	48
20. Bluegrass, 80; fescue, 10; redtop, 5; ryegrass, 5	80	87	78	78	83	78	77	78	64	74	66	49

*Average of two independent observations.

in each case. Turf in plots in which 90, 80, 70, 50, 30 and 10 percent, respectively, of Merion bluegrass were seeded contained averages of 89.3, 77.3, 55.8, 40.1, 26.4, and 10.5 percent, as shown in the last column of Table 2.

The percentages of Merion bluegrass were roughly proportional to the amount of Merion bluegrass seeded in the plots. However, the number of seeds of the competitive grasses sown in each case had a

TABLE 2—Relation of the percent of Merion bluegrass in seed-mixtures seeded August 1953 to the percent of Merion bluegrass plants in the turf in October 1954

Mixture	HN*-HC†	HN-LC‡	LN§-HC	LN-LC	Av. for each mixture	Av. for each group
Merion 100	100	100	100	100	100	100
Merion 90 Fescue 10	88	95	89	91	91	
Merion 90 Ryegrass 10	93	94	92	92	93	89.3
Merion 90 Redtop 10	81	90	81	85	84	
Merion 80 (Fescue 10, Ryegrass 5, Redtop 5)	80	78	77	74	77.3	77.3
Merion 70 Fescue 30	64	63	48	66	60	
Merion 70 Ryegrass 30	70	73	67	80	72.5	
Merion 70 Redtop 30	50	51	49	36	46.5	55.8
Merion 70 (Fescue 10, Ryegrass 10, Redtop 10)	66	67	64	60	64.3	
Merion 50 Fescue 50	58	44	40	43	46.2	
Merion 50 Ryegrass 50	55	42	69	60	56.5	
Merion 50 Redtop 50	31	17	13	14	18.8	40.1
Merion 50 (Fescue 30, Ryegrass 10, Redtop 10)	43	46	34	33	39	
Merion 30 Fescue 70	39	27	27	27	30	
Merion 30 (Fescue 30, Ryegrass 20, Redtop 20)	23	28	23	20	23.5	26.4
Merion 30 (Fescue 30, Ryegrass 10, Redtop 10)	25	28	29	21	25.8	
Merion 10 Fescue 90	16	8	6	12	10.5	10.5

*High nitrogen.
†High cut.
‡Low cut.
§Low nitrogen.

marked effect on the stand of Merion bluegrass; the greater the number of seeds of other grasses seeded, the lower was the percentage of Merion bluegrass in the turf.

The percentages of Merion bluegrass in the turf on plots seeded to mixtures containing redtop were much lower than on plots seeded to mixtures containing the same percentages of red fescue or ryegrass. The average percentages of Merion bluegrass in turf on plots seeded to the mixtures containing 10, 30, and 50 percent redtop were 84, 46.5, and 18.8; compared to 91, 60, and 46.2 percent and 93, 72.5 and 56.5 percent, respectively, in turf on plots seeded to red fescue and the ryegrass mixtures (as shown in column 5 in Table 2).

The greater competitive effect of redtop, compared to red fescue and ryegrass, was due largely to the greater number of redtop seeds per pound. There are approximately seven times as many redtop seeds per pound as red fescue and ten times as many as ryegrass; therefore, there were proportionately more redtop plants in each mixture containing this specie.

The competitiveness of Merion bluegrass with the other three species in the different mixtures which were used in this experiment was better under the higher level of nitrogen fertilization than under the lower level (Table 1). The percentages of Merion bluegrass in the turf on plots seeded with different mixtures of Merion bluegrass and creeping red fescue, domestic ryegrass, and redtop were higher in 31 out of 32 cases under high nitrogen levels than under low nitrogen fertilization.

Merion bluegrass plants in the plots receiving the higher nitrogen fertilization were greener and made more rapid recovery after cutting than those under the lower nitrogen feeding. Plots on which Merion bluegrass was seeded alone were covered with a dense, dark green turf by October 1954 under the higher level of nitrogen fertilization, but the turf under the lower level of nitrogen feeding had not completely covered the areas. Low nitrogen feeding favored the development of redtop in plots seeded with a mixture containing 50 percent redtop, with 45 and 43 percent Merion bluegrass in turf under high nitrogen, compared to 33 and 25 percentages in that under low nitrogen.

Height of cutting and nitrogen feeding had no appreciable influence on the percentage of Merion bluegrass in turf on plots in which the seeding mixtures contained over 80 percent Merion bluegrass seed. However, the Merion bluegrass content of turf seeded to

less than 80 percent was higher under high nitrogen feeding than under low nitrogen feeding in 17 out of 24 cases; it was lower in five cases, and equal in two (Table 1).

Merion bluegrass and creeping red fescue were about equally competitive in the early stages of growth, especially in the spring of the first year of establishment, April 1954. There was 58 percent Merion blue grass in the sod of the plot seeded with a mixture of 50 percent of each with high cut and high nitrogen feeding, 44 percent with low cut and high nitrogen, 43 percent with high cut and low nitrogen, and 40 percent with low cut and low nitrogen.

The percentage of Merion bluegrass in the turf maintained with high nitrogen levels increased by October, 1954 to 73 and 78 percent, but under low nitrogen the percentage decreased to 25 and 35. The

TABLE 3—Percentage of weeds occurring in pure species and mixtures under four different treatments in field plots.*

Mixtures	Treatments			
	Nitrogen-high		Nitrogen-low	
	1 ½″ cut	¾″ cut	¾″ cut	1 ½″ cut
	Percentage of weeds			
1. Merion bluegrass, 100	0	0	1	3
2. Creeping red fescue, 100	2	3	5	3
3. Redtop, 100	0	0	3	2
4. Domestic ryegrass, 100	8	10	20	18
5. Bluegrass, 90; fescue, 10	0	0	3	2
6. Bluegrass, 70; fescue, 30	0	0	3	2
7. Bluegrass, 50; fescue, 50	0	1	3	3
8. Bluegrass, 30; fescue, 70	0	1	5	4
9. Bluegrass, 10; fescue, 90	1	3	8	6
10. Bluegrass, 90; redtop, 10	0	0	2	4
11. Bluegrass, 90; ryegrass, 10	1	2	10	25
12. Bluegrass, 70; redtop, 30	0	0	5	4
13. Bluegrass, 70; ryegrass, 30	2	5	10	10
14. Bluegrass, 50; redtop, 50	0	1	5	5
15. Bluegrass, 50; ryegrass, 50	5	10	15	14
16. Bluegrass, 50; fescue, 30; redtop, 10; ryegrass, 10	1	2	5	3
17. Bluegrass, 30; fescue, 30; redtop, 20; ryegrass, 20	1	2	5	4
18. Bluegrass, 30; fescue, 50; redtop, 10; ryegrass, 10	1	1	3	3
19. Bluegrass, 70; fescue, 10; redtop, 10; ryegrass, 10	0	1	3	3
20. Bluegrass, 80; fescue, 10; redtop, 5; ryegrass, 5	1	1	3	3

*Average of two independent observations.

higher cutting, 1½ inch, increased the competition from the red fescue. There were 10 percent more red fescue plants in the plot cut high than in the one cut low.

The factors which favored the development of weeds during the establishment of the Merion bluegrass turf are indicated by the data in Table 3. They were: (1) close mowing, (2) low nitrogen feeding, and (3) open turf due to the presence of coarse competitive grass, in this case, domestic ryegrass.

Plots in which Merion bluegrass was seeded alone and where the high level of nitrogen was maintained produced a weed free turf. No weeds, either grassy or broad leaved, had appeared by October 1954, 1 year after seeding, regardless of height of cut.

The turf on the plots which were seeded with domestic ryegrass and mixtures of it with other grasses were all badly infested with weeds, plantain, dandelions and crabgrass. The development of weeds in these plots was approximately proportional to the percentages of domestic ryegrass in the seeding mixtures.

Low nitrogen feeding and close mowing favored the development of weeds in all of the plots.

DISCUSSION

The practice of mixing grass species which germinate quickly and which make a rapid initial growth with grass species which are desired for a permanent sod has been considered a questionable practice by many turf research workers. Merion bluegrass seed is relatively expensive compared to other desirable lawn grass species such as common Kentucky bluegrass, creeping red fescue, and bentgrasses. Its development increased the need for documented information as to the beneficial and detrimental effects of mixing it with seeds of other grass species for planting turfgrass areas.

The finest quality Merion bluegrass turf is dark green, dense, even-textured, and free of weeds. The results of this study indicate that to obtain such quality: (1) Merion bluegrass seed should be sown alone in early fall (August 15 to September 1); (2) the turf should be maintained under a high level of nitrogen fertilization, at least 5 pounds of actual nitrogen per 1,000 square feet of area during the growing season; (3) it should be cut at a height of 1¼ to 1½ inches; and (4) it should be watered only when necessary. The grass on these plots was watered only three times during the 1954 season, but the

soil was soaked thoroughly to a depth of approximately 6 inches each time.

Domestic ryegrass and redtop seeds are included in the seed mixtures designed for turfgrass areas not because they are the species of grasses desired in the turf, but because they germinate quickly (5 to 10 days) and grow rapidly during the early stages.

These grasses conduce a quick ground cover which: (1) satisfies those lawn growers who measure the quality of the lawn by the shortness of time between seeding and the appearance of green plants; (2) reduces the length of time the soil is without cover and, therefore, lessens danger of erosion and loss of seed by washing from heavy rainfall; (3) presumably prevents the development of weeds by competition and protects the slower germinating and slower starting desired permanent lawn grass; and (4) reduces the cost per pound of seed.

Domestic ryegrass is less desirable than redtop in grass seed mixtures for turf purposes, although the data clearly indicate it is less competitive. Turf in all plots in which it was planted was rough and bunchy in appearance because ryegrass plants are taller and have larger, coarser leaves and stems than do the other grasses. Turf on plots in which ryegrass was present was less dense and well-knit than the others, so that weed encroachment was greater than on other plots. Turf produced from a seed mixture containing only 10 percent domestic ryegrass seeds was the least desirable from an appearance standpoint.

Since it was composed mostly of annual ryegrass, domestic ryegrass had largely disappeared from the mixtures by fall of 1954, leaving open spaces in the turf.

Redtop was more competitive than ryegrass where sown in mixtures with Merion bluegrass (as shown by the data in Table 1). This may be due to the greater number of individual seeds planted per unit area rather than to the competitive ability of the species. However, redtop and Merion bluegrass mixtures formed dense, neat appearing turf, compared to the rough, bunchy turf produced by mixtures containing ryegrass.

Redtop was less drought-tolerant than Merion bluegrass and ryegrass, and tended to turn yellow unless water was added during dry periods. This yellow color was intensified as the percentage of redtop in the mixture was increased, especially under the low nitrogen level.

Creeping red fescue is not planted in mixtures with Merion bluegrass to serve as a nurse grass nor, primarily, to lower the cost per pound of the seed. Its function is to act as a supplementary grass to produce a denser, more hardy turf with better season-long quality than could be attained by either of them alone.

Creeping red fescue greens up earlier in the spring and presents a more pleasing appearance than Merion bluegrass at that time. It also is better able to endure summer heat and drought under low nitrogen levels, as shown by the marked decrease of Merion plants in the turf on all plots where more than 10 percent creeping red fescue was seeded. However, under high nitrogen feeding and cool, moist conditions in the fall, Merion bluegrass made more vigorous growth than did red fescue, the percentages of Merion bluegrass increasing over those found earlier in the season on the same plots. However, the percentages of Merion bluegrass decreased in all cases when these grasses were maintained under a low level of nitrogen feeding.

Red fescue seeded singly and in mixtures with Merion bluegrass under high nitrogen levels was seriously injured by an unknown factor. The same was true of red fescue turf on other plots on the University Farm. The turf turned brown and died in small irregular circular spots 3 to 6 inches in diameter. The causal organism or factor was not identified. It was not injurious under the low level of nitrogen.

The results obtained in the field and in the greenhouse (Juska et al., 1955) are in close agreement: (a) Redtop was the most competitive species used in mixtures with Merion bluegrass, followed in order by creeping red fescue, with domestic ryegrass being least competitive; (b) Merion bluegrass grows about as well where mowed at a height of ¾ inch as at 1½ inches; (c) as the percentage of Merion bluegrass seed in the mixture decreased, the percentage of Merion bluegrass in the sod decreased; (d) growth and vigor of Merion bluegrass increased more under high nitrogen feeding than did the other grasses.

CONCLUSIONS

Merion bluegrass should be seeded by itself on all turfgrass areas where there are no shade trees or shrubs to compete with the grass and if the other conditions are capable of maintaining a reasonable supply of available moisture to meet its growth requirements. A high level of nitrogen feeding should be maintained, regardless of height of cut.

Creeping red fescue or any other good strain of red fescue should be used if the soil conditions are generally droughty. It will grow better than other varieties on coarse-textured soils without supplemental irrigation, on areas where roots of trees and shrubbery compete for water and plant food, and on all areas, regardless of soil, where low levels of nitrogen feeding are to be used.

A mixture of 75 percent Merion bluegrass and 25 percent creeping red fescue could be used advantageously where there are mixed environmental conditions. Merion bluegrass will be the predominant grass where growth conditions are more favorable for it; red fescue will predominate where conditions favor its growth.

There is no advantage in using seed mixtures containing redtop and domestic ryegrass because Merion bluegrass seeded alone produced the most beautiful season-long turf when properly maintained with high nitrogen feeding. Red fescue produced the best turf under low nitrogen feeding.

SUMMARY

1. Merion bluegrass was seeded alone and in mixtures containing varying percentages by weight and combinations of creeping red fescue, domestic ryegrass, and redtop. The seed of each of the individual species and of each of the mixtures was sowed at the rate of *1 pound* per *1,000 square feet* of turf area.
2. Where seeded in mixtures with Merion bluegrass, each of the other grasses reduced the percentages of the former found in the turf, regardless of nitrogen fertilization or mowing practice. Redtop was the most competitive; domestic ryegrass was the least.
3. The proportions of Merion bluegrass to both creeping red fescue and redtop increased from spring to fall in all plots where mixtures of these grasses were planted and maintained under a high nitrogen level; under the low level of nitrogen feeding, the opposite was true. On the other hand, domestic ryegrass had almost completely disappeared by October 1954.
4. Weed infestation was higher in plots where the grass was mowed at the ¾-inch height than at the 1½-inch height except in the case of Merion bluegrass; it was higher in plots receiving low nitrogen fertilization than high nitrogen fertilization, and higher in those plots in which domestic ryegrass was planted than in the others.

5. In mixtures with all other species, Merion bluegrass was more competitive under the high level than under the low level of nitrogen fertilization.
6. A dense, medium-textured, dark green, weedless, Merion bluegrass turf was more quickly and better established under the high level of nitrogen feeding where no other grasses were planted with it than where mixtures were employed.
7. Mowing at a height of ¾ inch was not detrimental to the establishment of Merion bluegrass.
8. Creeping red fescue was severely injured by mowing at the ¾-inch height.
9. Domestic ryegrass disappeared almost completely during the first season from plots which were mowed at a height of ¾ inch.

LITERATURE CITED

Carroll, J. C. (1943). Effects of drought, temperature and nitrogen on turf grasses. Plant Physiology 18(1): 19-35.

Graber, L. F. (1929). Penalties of low food reserves in pasture grasses. Jour. Amer. Soc. Agron. 21(1): 29-34.

Harrison, C. M., and C. W. Hodgson (1939). Response of certain perennial grasses to cutting treatments. Jour. Amer. Soc. Agron. 31(5): 418-430.

Juska, F. V.; J. Tyson and C. M. Harrison (1955). The competitive relationship of Merion bluegrass as influenced by various mixtures, cutting heights, and levels of nitrogen. Jour. Amer. Soc. Agron. 47(11): 513-518.

Morrish, R. H., and C. M. Harrison (1948). The establishment and comparative wear resistance of various grasses and grass-legume mixtures to vehicular traffic. Jour. Amer. Soc. Agron. 40(2): 168-179.

Mortimer, G. B., and J. L. Ahlgren (1936). Influence of fertilization, irrigation and stage and height of cutting on yield and composition of Kentucky bluegrass. Jour. Amer. Soc. Agron. 28(7): 515-533.

Tyson, J., (1954). Michigan Agr. Expt. Sta. Unpublished data.

FARM PRICES AND FARM EARNINGS IN MICHIGAN, 1929-1954

By K. T. WRIGHT

DEPARTMENT OF AGRICULTURAL ECONOMICS

CHANGING PRICES, weather conditions and other factors cause farm earnings to vary considerably from year to year. Many persons feel that the variations in prices received and paid by farmers are the major factors. Various reports are published showing prices received by farmers and gross farm income in Michigan, but very little is available showing prices paid, farm expenses and net farm earnings.

It is the purpose of this article to show the relationship between: (a) prices received by farmers and gross farm income; (b) prices paid and total farm expenses; and (c) the parity ratio of farm prices to net farm earnings. Since farm account records are available beginning with 1929, this article will deal with the period 1929-54.

RELATION BETWEEN PRICES RECEIVED AND GROSS FARM INCOME

During the 26 years from 1929 through 1954, prices received by farmers in Michigan varied widely, as they have in most other periods of that length. They averaged 158 percent of 1910-14 in 1929, dropped to 67 percent in 1932, and reached a peak of 289 percent in 1948 (Fig. 1). Since 1948, the index of prices received has been declining and averaged 233 for 1954.

Average annual gross income per farm in the Michigan Farm Business Analysis Extension Project[1] also fluctuated widely. This has been

[1]Based upon 500 to over 1,000 farms in different years. These farms were larger than average, and crop and livestock yields likewise were above average. Detailed figures on size of farm, investment, crop and livestock production, and income and expenses in recent years are presented in this issue in another article "Changes in Farming, 1945-54, as Shown by Michigan Farm Account Records" pages 664-678.

ARTICLE 38-72

plotted in Fig. 1, along with the index of prices received, in such a manner that the variations could be compared. This was done by graphing gross income at the same level as the index of prices received when the index was about 100 in 1939 and 1940, then setting up a gross income scale proportional to the price scale.

A study of this graph shows that before 1939, gross income per farm was less than would be expected from the prices received. For the 10-year period 1939 to 1948, gross income per farm and prices received both increased at about the same rate. The relationship

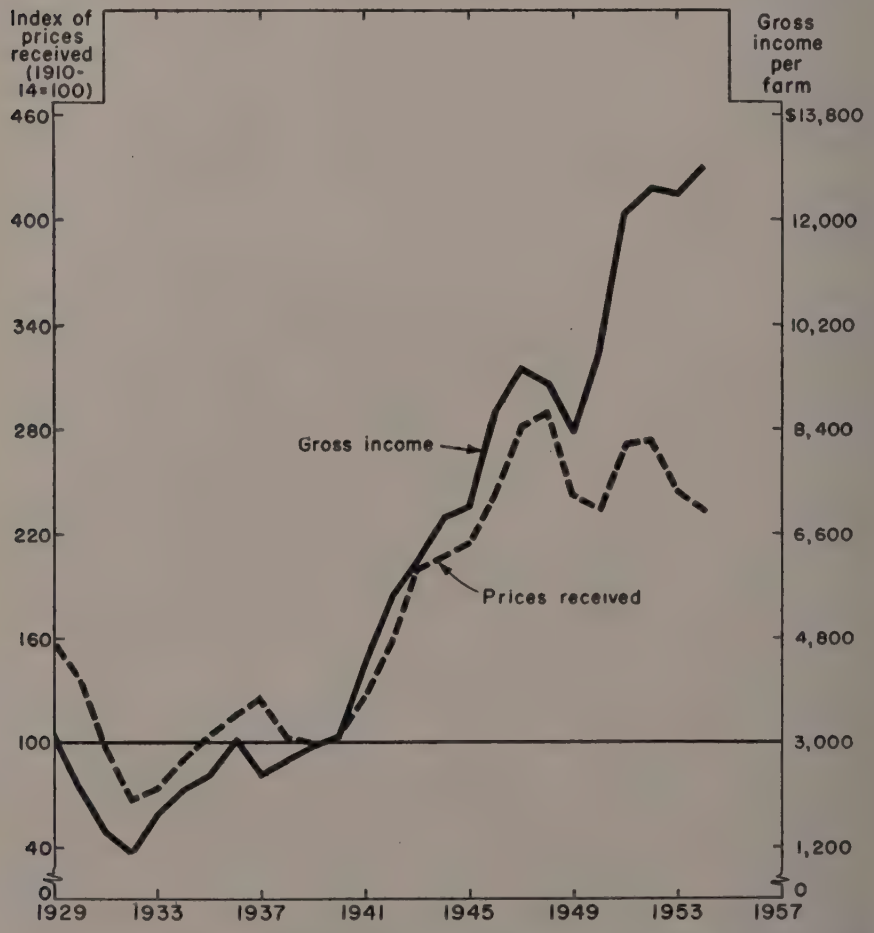

Fig. 1. Index of prices received by farmers in Michigan and gross income per farm, account farms 1929-54.

since 1948 has deviated markedly from the preceding 10 years. Gross income per farm has risen much higher than would be expected from the prices received by farmers for their products.

There are several possible reasons for this relatively higher income: larger farms, higher crop and livestock yields, and the like. These will be explored later.

RELATION BETWEEN PRICES PAID AND TOTAL FARM EXPENSE

No index of prices paid by farmers for the commodities they use in production and living is computed for Michigan alone. Thus, the United States average was the only index available for use in this study. This index, like the one for prices received, showed much variation during 1929-54.

The index of prices paid in 1929 averaged 160, practically the same as for prices received (Fig. 2). Prices paid declined during the years of the depression, but less than prices received, dropping only to 109 percent of 1910-14 in 1933. They have been rising more or less steadily since 1939, reaching a peak of 287 in 1952, with only a slight decline since.

Farm expenses in this discussion include cash farm operating expenses, depreciation on buildings and fences, a charge for family labor, and a charge for the labor of the farmer at hired man's wages. (It does not include interest paid or an interest charge on the farm investment.)

Total farm expense has been graphed in essentially the same manner as the gross income, with 1939 and 1940 approximating 100. Total farm expenses are graphed at 75 percent of gross income, which was the 26-year average. (Farm expenses in 1954, however, were 88 percent of the gross income on these farms, the highest percentage in the 26 years outside of 1930-32.)

Fig. 2 shows that the total farm expense was proportionately lower than prices paid by farmers from 1929 to 1942. Since then, however, total expenses per farm have risen more rapidly than prices

paid, especially in recent years. Here again, as with the relationship between prices received and gross income, some of the difference between prices paid and total expense per farm in recent years was due to change in size of farm and the level of inputs per acre. These will be examined later.

The rise in expenses per farm from 1942 to 1951 was proportional to the rise in gross income. Since 1951, however, farm expenses have continued to rise sharply, while gross income per farm increased but

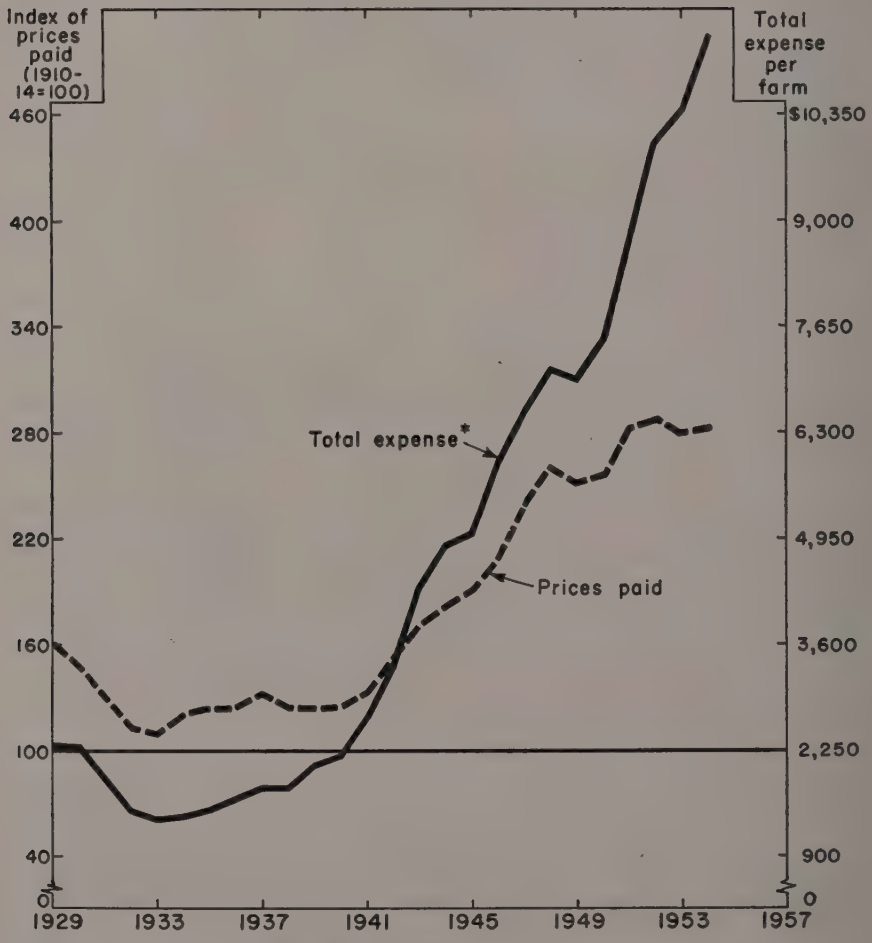

Fig. 2. Index of prices paid by farmers and total expense per farm, account farms, 1929-54.

*Includes all expenses as well as a charge for operator's labor at hired man's wages.

little. By 1954, average gross income on these farms averaging 230 acres was $12,899 while the total expense was $11,335, leaving $1,564 for interest on investment of about $50,000 and for management.

RELATION BETWEEN PRICES RECEIVED AND GROSS INCOME PER ACRE

It has been pointed out that some of the deviation between prices received and gross income per farm may have been due to a change in the average size of the farm operated by the men in this project. At the start of this project in 1929, the average size of cooperators' farms was 159 acres, with 107 acres tillable. By 1940, the average was 170 acres and 112 tillable; by 1950, it was 201 acres with 138 tillable. In 1954, the average size had increased to 230 acres, with 166 tillable. In view of this change in size, the gross income and total expense have been figured on a tillable acre basis.

In Fig. 3, the index of prices received by farmers and gross income per tillable acre have been graphed on as nearly a comparable basis as possible. It can be seen that from 1933 through 1949 the variations in the two have been quite similar. Since 1949, gross income per acre has been higher than would have been expected from the prices received.

A study of the changes taking place on these farms from 1945 to 1954 has shown that the farmers in 1954 were keeping about 10 percent more livestock per acre than in 1945. Not only that, but the production per head was roughly 20 percent higher. Crop yields per acre likewise were about 25 percent higher in 1954 than in 1945. The combined effect of these changes resulted in about one-third higher output per acre, and raised the income from a probable $59 per tillable acre in the farm to $78 in 1954.

RELATION OF PRICES PAID AND EXPENSE PER ACRE

Since about 1940, the total expense per acre on the farms in this study has been increasing faster than prices paid (Fig. 4). This was especially marked in the last 4 or 5 years. In 1954, total expenses at $68 per tillable acre were about $12 (approximately 20 percent) higher than would have been expected from the index of prices paid.

The question is, why should expenses per acre in recent years be

proportionately higher than prices paid, especially if farmers are now more efficient than formerly? One explanation would be more intensive operation. For instance, having more livestock per acre and obtaining higher crop yields would likely call for greater inputs per acre. Similarly, the higher livestock rates of production per head would require greater inputs. This is borne out by an inspection of the expenses per acre for fertilizers, seeds, and feeds.

Fig. 3. The top graph shows index of prices received by farmers in Michigan and gross income per tillable acre, account farms 1929-54.

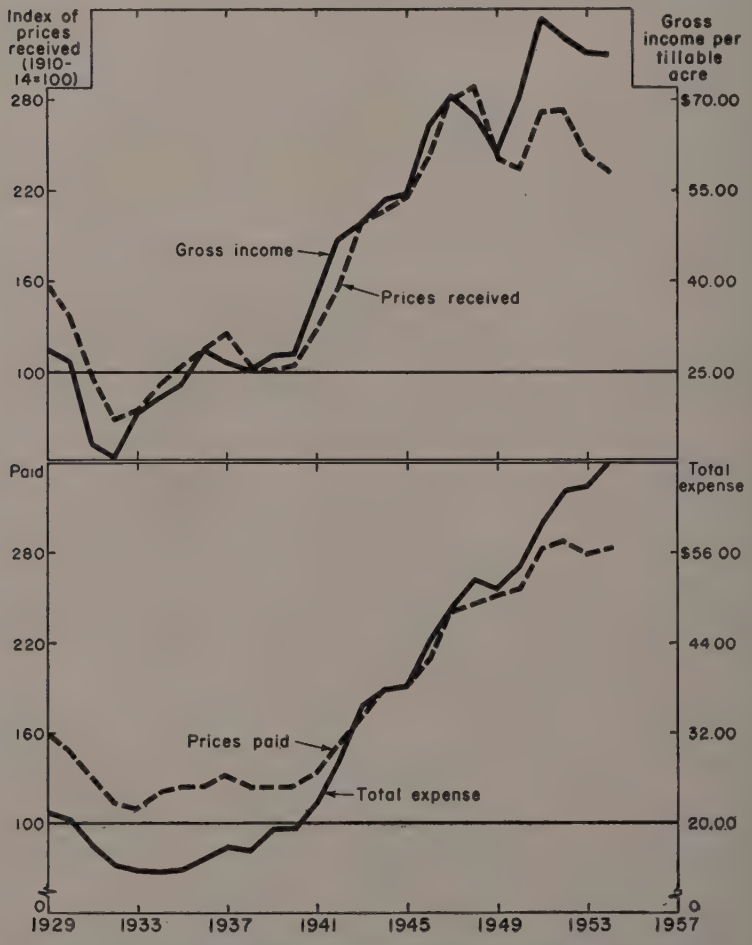

Fig. 4. The bottom graph shows index of prices paid by farmers and total expense per tillable acre, account farms 1929-54.

But what about any change in efficiency of production in these recent years, especially with respect to labor and machinery use? The charge for all labor rose from $19.77 per tillable acre[2] on these account farms in 1949 to $22.08 in 1954. Production of farm products per man, however, was about 50 percent higher in 1954 than 5 years before.

The expenses of operating farm machinery, plus its annual depreciation, average about $11 per tillable acre in 1949 and over $16 in 1954, a 50 percent increase in 5 years. Expressed in another manner, machinery costs per farm in 1949 were 64 percent as much as the labor charge; but by 1954 they were 84 percent of the labor charge. Farmers have been investing in machinery to save labor. The combined charge for labor and machinery to produce $100 of income on these farms in 1949 averaged $50; by 1954, this still remained at $50.

Total expenses of operating these farms in 1954 were about 35 percent more than 5 years earlier, even though prices paid increased only 12 percent. There appears to have been intensification of inputs per acre in the past 5 years and a change in the relative importance of the various expenses. This has resulted in much higher fixed costs, making adjustments downward to the lower farm prices very difficult.

RELATION OF PARITY RATIO TO LABOR INCOME

It has been shown in Figs. 3 and 4 that during the 1940's there was a fairly close relationship between prices received and farm income per acre, and between prices paid and farm expenses per acre. It follows that there should be a similar relationship between the ratio of prices received to prices paid (frequently called parity ratio) and net farm earnings. (Parity ratio is based upon the 1910-14 indexes of prices received and paid by farmers. If prices received are higher than the prices paid, then the parity ratio is above 100.)

The parity ratio of farm prices in Michigan, shown in Fig. 5, varied from about 100 in 1929 to a low of 60 in 1933 and to a high of 117 in 1947. By 1954, it had declined to 83.

Net farm earnings are indicated by labor income. This is the amount left for the farmer for his own labor and management after deducting operating expenses, depreciation on buildings and machinery, a charge for unpaid family labor, and 5 percent interest on the farm investment.

In Fig. 5, the parity ratio has been graphed from 1929 through 1954. Labor income on account farms in Michigan is superimposed on as nearly a proportional scale as could be developed. Labor income

[2]Revised from that published in annual reports to more accurately reflect increasing wage rates.

declined and rose nearly the same as the parity ratio from 1929 to 1949. Since 1949, the relationship has not been as close as in previous years. Labor incomes were unusually high in 1951 and fell much more rapidly than the parity ratio since then.

CORRELATION ANALYSIS RESULTS

To more thoroughly study the relationship between parity ratio and labor incomes on the farm account farms, linear correlations were calculated, using the conventional regression analysis equation of $Y = a + bX$. In this case "Y" was labor income, "a" the constant, "b"

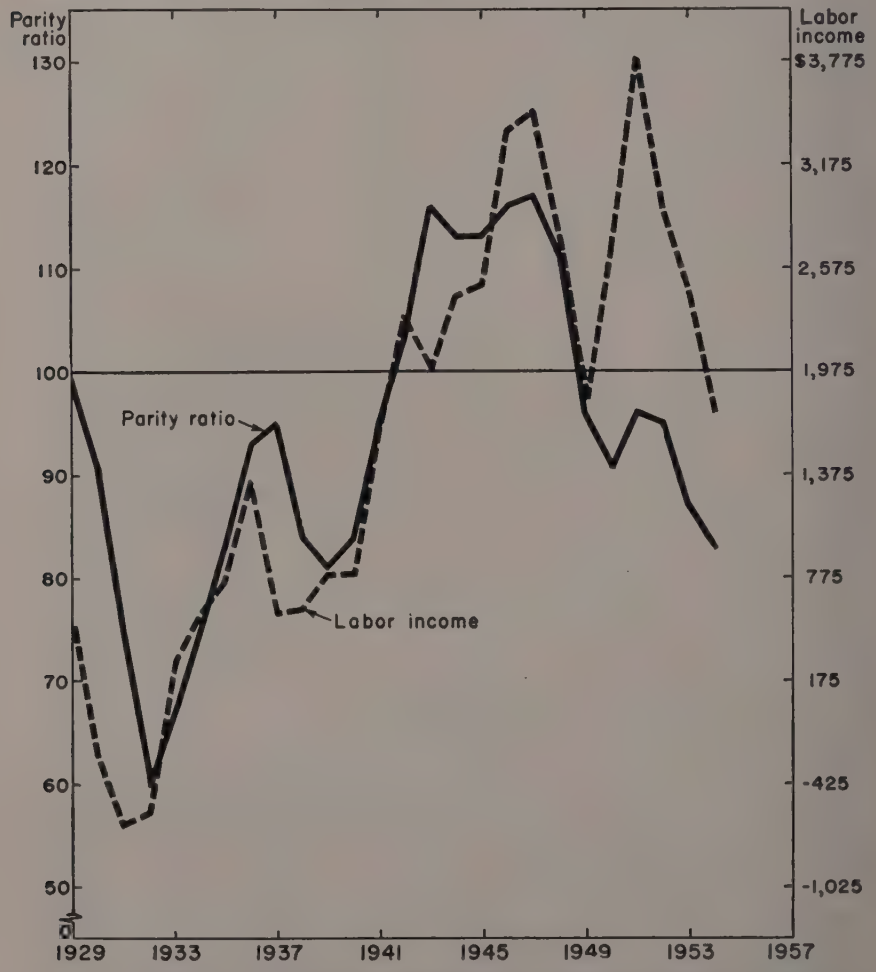

Fig. 5. Parity ratio of prices received and paid by farmers and labor incomes on account farms, Michigan 1929-54.

the rate of change in labor income, and "X" the parity ratio of farm prices in Michigan.

As an average for the entire period from 1929 through 1954, Y = —$4,051 + $60.29X. In other words, one point change in the parity ratio changed the labor income $60.29. The average labor income in many years, however, differed greatly from the average regression or relationship line, resulting in a standard error of $865 in labor income. The correlation coefficient (r) was 0.730, indicating only fair relationship.

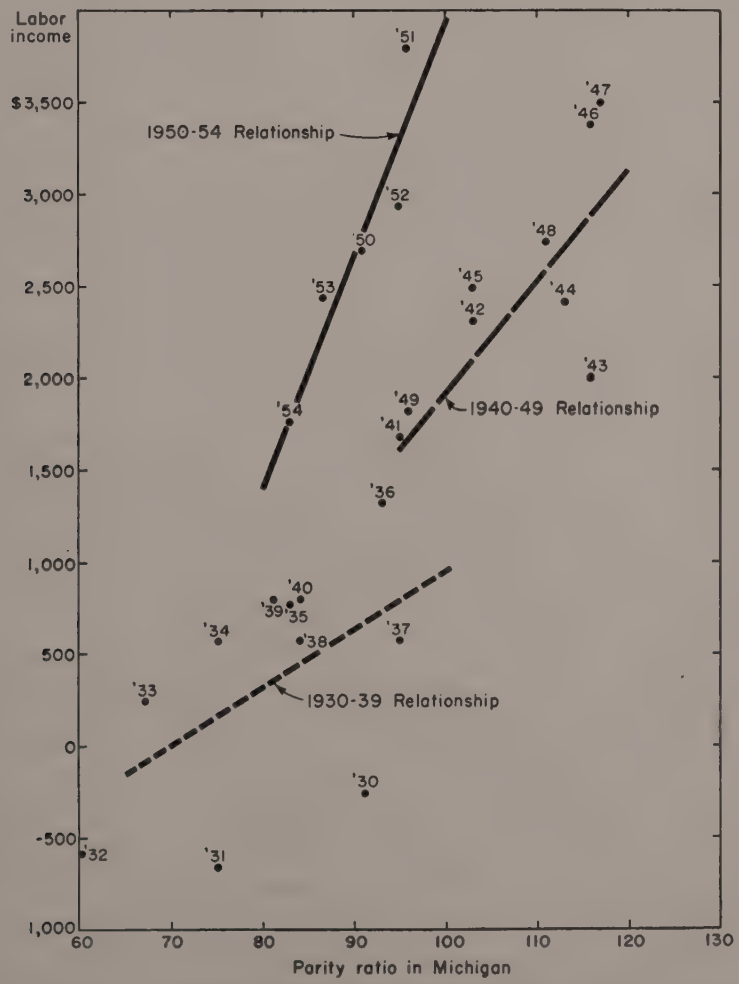

Fig. 6. Relationship between parity ratio and labor incomes, account farms, Michigan, 1930-54.

Further study of the data indicated the desirability of dividing the 26 years into three periods, 1930-39, 1940-49, and 1950-54.

The 1930-39 Relationship — During this period, the average relationship was Y= —$2,172 + $31.10X (See Fig. 6). According to this, when the parity ratio was 100, the labor income would be expected to be $938 (—$2,172 + ($31.10 x 100 or $3,110). There were, however, wide variations in the actual average labor incomes during this period, as can be seen from the graph; and the standard error was $513. The correlation coefficient was only 0.546, indicating little relationship between parity ratio and labor incomes during this period.

The 1940-49 Relationship — In this period, both parity ratios and labor incomes were generally much higher than in the preceding decade (Fig. 6). The average relationship during this period was Y = —$4,123 + $60.42X. One point change in the parity ratio had about twice the effect on labor incomes as in the preceding 10 years. In this period, a parity ratio of 100 resulted in an expected labor income of $1,919 on the farms included in the study.

The variation of the average annual labor income in this decade was much less than in the preceding period, and the standard error was $398. That is, about two-thirds of the years could be expected to be within that amount of the labor income shown by the relationship line for the parity ratio of these years. The correlation coefficient was 0.853 during this period.

The 1950-54 Relationship — In this 5-year period, parity ratios were generally lower than in the preceding decade, and labor incomes changed violently. It will be recalled that there were marked divergences in this period from previous relationships between prices received and farm income, and between prices paid and farm expenses.

During these 5 years, the average relationship between parity ratio and labor incomes was Y = —$8,614 + $125.38X. In other words, one point change in the parity ratio meant a change of $125.38 in the labor income; 10 points, a $1,253 difference. This was twice the effect it had in the previous decade. Also, a price relationship of 100 percent parity in this period would be expected to result in an average labor income of $3,924 on large, well-managed farms such as those in this study.

The average labor income in the various years of this period did not differ from the average line of relationship as much as in the

two previous periods. In this period, the standard error was only $246, and the coefficient of correlation was 0.928.

Looking at the relationships of parity ratio to labor incomes on the more than 500 farms in this study during these three periods, it appears that 100 percent parity prices during the 1940's resulted in about $1,000 higher labor incomes than in the 1930's, and about $3,000 higher during the 1950-54 period. The higher coefficients of correlation in the 1940's and 1950's also indicate a much closer dependence of earnings upon the parity ratio of farm prices, or, since prices paid have been relatively stable, upon prices received by farmers.

Many factors have been responsible for these changes. Some of the more important appear to be: The increase in the size of farm operated, the increase in crop and livestock yields, the very rapid increase in production per man (especially in recent years), the marked increase in machinery investment and operating cost per farm, and the increase in the proportion of the farmers' expenses which are fixed costs.

SUMMARY

This analysis of the relationships between: (1) prices received by farmers and gross income of the group of farmers studied; (2) prices paid by farmers and farm expenses; and (3) parity ratio of farm prices to farm earnings, brings out the following points:

1. Gross income per farm since 1949 has been relatively higher than prices received, due to the farmers operating larger farms and their getting greater output per acre.
2. Total expenses per farm have been rising more rapidly than prices paid by farmers for the past 15 years, and particularly in the past 5 years, again due to the increase in size of the farm and to greater inputs per acre.
3. Gross farm income and total expenses per tillable acre have increased much more rapidly in the past 5 years than prices received and prices paid, largely due to greater intensity of operation.
4. The effect of the parity ratio of farm prices on labor incomes on the farms studied was twice as great during 1950-54 as during 1940-49, and the correlation was closer.
5. Increased size of farm, improved yields, greater output per man, increased machinery investment and cost of operation per farm, and increased fixed costs have apparently increased farm earnings from the same parity ratio, but made those earnings more dependent upon price relations.

JOURNAL ARTICLE ABSTRACTS

Urinary Excretion, Tubular Reabsorption and Biliary Excretion of Cobalt 60 in Dogs

LEE, CHENG-CHUN, AND L. F. WOLTERINK

Am. Jour. Physiol. 183: 167-172. 1955. (Journal Article 1376 from the Michigan Agricultural Experiment Station)

Surgical operations in four sodium pentobarbital anesthetized dogs were made so that the hepatic bile and urine from both kidneys were collected. After single intravenous injections of about 10 μc of $Co^{60}SO_4$, per kg. body weight, between 40 and 70 percent of the injection dose was recovered in urine plus bile during a period of 7 to 13 hours. About 85 percent of this was recovered during the first 6 hours. Only one-eighth of this total recovery was found in the bile.

The urinary Co^{60} concentrations and renal clearance values decreased toward the end of the experiments, while the biliary Co^{60} concentrations and hepatic clearance values increased. This indicates that the ability of the liver to handle this tracer in acute experiments remains unimpaired longer than that of the kidneys. The ability of the liver to excrete Co^{60} at the end of the experiment (7 to 13 hours) is as good as or even better than at the beginning.

At the end of the experiments, concentrations of the tracer in the urine were from 110 to 120 times the blood concentrations. In the most extreme case, a high peak blood/urine concentrations ratio of 1:1225 was reached in 30 minutes. The final concentrations of the tracer in hepatic bile were from 25 to 240 times the blood concentrations.

Metabolism of Colbalt 60 in Chickens

LEE, CHENG-CHUN, AND L. F. WOLTERINK

Poult. Sci. 34: 764-776. 1955. (Journal Article 1554 from the Michigan Agricultural Experiment Station)

One caecum, both caeca and/or large intestine were tied off from the small intestine in the chicken through an abdominal incision. Twenty micrograms of Co^{60}, as $Co^{60}SO_4$, per kg. body weight were injected intravenously or directly into the gizzard. It is both readily absorbed from the intestinal tract and "secreted" or "continuously diffused" into the intestinal tract through its well.

Twenty-four hours after administration, 6 percent of the injected dose may be recovered from the small intestine, 5 percent from both caeca, 1 percent from the large intestine, and 5 percent from the extracellular fluid. During this period, if the Co^{60} is injected intravenously, at least 13 percent of the injected dose is eliminated in the feces. A large fraction of the remaining 70 percent is excreted in urine emptied into the cloaca. If the Co^{60} is injected into the gizzard, at least 51 percent appears in the feces and a fraction of the remaining 32 percent appears in the urine by the end of 24 hours.

Most of Co^{60} found in the caecum enters from the gut. However, under certain experimental conditions, Co^{60} passes into the caecum through the wall in large amounts. Co^{60} is greatly concentrated in the caecal contents, in the

caecal wall, and in the small and large intestines regardless of the route of administration. In these locations, it is present in some non-diffusible form or forms. A very small amount of Co^{60} is found in the bladder bile.

Growth of Greenhouse Roses as Affected by Mulches and Mixtures of Ground Corncobs

CARPENTER, W. J., AND D. P. WATSON

Am. Rose Annual. pp.45-53. 1955. (Journal Article 1598 from the Michigan Agricultural Experiment Station)

Four hundred rose plants of the variety Better Times planted in two greenhouse benches were subjected to five different conditions and combinations of ground corncobs and soil.

Immediately following the application of freshly ground corncobs as either surface mulches or soil mixtures, a large reduction in the nitrate level of the soil occurred.

While the mulch of corncobs seemed to be the cause of reducing the amount of linear growth early in the experiment, after a period of 18 months the greatest growth was found in treatments where either 2-or 4-inch mulch was present.

Flower yield was increased by the use of corncobs as a mulch or by corncobs mixed with the soil. The highest yield was obtained on plants grown under a 4-inch mulch of corncobs, but the quality of flowers (as measured by centimeters of stem length and the number of grams per flower) was perhaps influenced more by the season of the year than by the corncobs used on or in the soil.

On this basis, flowers of the highest quality were produced during the fall and winter months. Growth and production records indicated that the beneficial effect of mulch occurred during the spring and summer.

The Freezing Microtome in Sectioning Plant Ovules for Embryological Examination

TEUBNER, F. G.

Stain Tech. 31: 95-96. 1956. (Journal Article 1648 from the Michigan Agricultural Experiment Station)

A technique is described for employing the freezing microtome to obtain plant ovule sections which contain intact embryos. The method is applicable to very early stages of embryo development which are difficult to examine by other means. The most important feature of the method involves arrangement of the ovule in the embedding medium so that the micropylar end is pointing toward and is perpendicular to the cutting edge of the microtome blade. Satisfactory sections are obtained when cut at 25 to 50 microns and may be examined for embryological detail after staining with Delafield's hematoxylin.

Beta-Propiolactone as a Virus Altering Agent for a Newcastle Disease Vaccine

MACK, W. N., AND ACHIT CHOTISEN

Poult. Sci. 34: 1010-1013. 1955. (Journal Article 1712 from the Michigan Agricultural Experiment Station)

When allantoic fluid containing Newcastle disease virus was treated with 0.025 percent beta-propiolactone, it was found that when the virus was injected

into chickens, it was no longer infectious. Blood sera tested before and after the injection of this material demonstrated a rise in the hemagglution titer against Newcastle disease virus.

Forty-three birds vaccinated with the beta-propiolactone-virus mixture and 39 control birds were challenged with virulent virus 16 days after the former group were vaccinated. All 43 vaccinated birds remained well; in the unvaccinated group, 97.4 percent developed symptoms of Newcastle disease or died.

Advantages of this type of vaccine are discussed.

Effects of Controlled Root Temperatures on the Growth of East Malling Rootstocks in Water Culture

NELSON, S. H., AND H. B. TUKEY

Jour. Hort. Sci. 31: 55-63. 1956. (Journal Article 1744 from the Michigan Agricultural Experiment Station)

To study the effect of root temperature on the growth of six apple rootstock varieties, five East Malling clones and one rootstock of seedling origin were grown in nutrient solutions at 44°, 55°, 66° and 77°F., but at the same air temperature.

The onset of new growth in shoot and root was accelerated by a rise in temperature from 44° to 77°F.

Definite differences in root production were evident. All rootstocks showed very slight root growth at 44°F.; root growth in M.VII, M.XVI and seedling rootstocks increased as the temperature was raised from 44° to 77°F., while greatest root growth in M.I, M.II and M.IX was at 55°F. All of the last two rootstocks were killed at temperatures above 55°F.

The cortex of those plants that grew better at low temperatures was severely browned, ruptured and often sloughed at high temperatures. This condition was not so marked in varieties tolerant of high temperatures.

At 44°F., the roots were thick, pearly white and non-branched, while at 77°F. they were slender, much branched, and more or less discolored.

Shoot growth was proportional to root growth. Shoots of M.I, M.II and M.IX were longest at 55°F. M.XVI was almost equally tolerant to 55°, 66° and 77°F., but growth was slightly greater as the temperature increased. The most extensive top growth was at 66°F. for M.VII and at 77°F. for the seedlings.

Raising the root temperature from 44° to 77°F. increased root cell maturation, as illustrated by differentiation of primary tissues, vascular cambial activity and subsequent deposition of secondary tissues. The highest root temperature also increased browning and sloughing of the cortex.

Several of the East Malling rootstocks tested appear to prefer a relatively cool root temperature. It is suggested that this factor be further explored on the North American continent, where soil temperatures over large areas are relatively high for extended periods.

Glamorous vs. Profitable Feeding of Dairy Cattle

HOGLUND, C. R.

Jour. Dairy Sci. 39: 109-112. 1956. (Journal Article 1747 from the Michigan Agricultural Experiment Station)

Dairy farmers will need to put more emphasis on economy in feeding dairy

cows if they are to profit from their operations. From an economic standpoint, there is no one most profitable level of feeding for all times.

The optimum quantity of grain (concentrates) and roughage to feed is not fixed. Rather, it is determined by such important factors as (1) the production response of cows differing in inherent productivity, (2) the quality of roughage fed, and (3) the price relationships between feed and milk.

Dairymen will need to become more familiar with the principle of diminishing returns so they can more accurately determine the optimum combination and quantity of grain and roughage to feed. They will also need to keep more complete production records on individual cows. This will enable them to adjust feeding rates to price changes.

Evaluation of Dust Deposits by Polarography

BAN, N. T., AND W. M. CARLETON

Ag. Eng. 36: 803-805. 1955. (Journal Article 1769 from the Michigan Agricultural Experiment Station)

The polarographic method for chemical analysis is applied to the evaluation of agricultural dust deposits.

A brief discussion on polarography and on necessary instrumentation is presented. The polarographic method was compared with the electrolytic method. The method was tested both in the laboratory and in field work, using copper sulfate as dust.

Copper concentrations as low as 1 p.p.m. were readily measured.

The method is considered to have merit because it involves relatively simple chemical manipulations; it is fast, and it may be applied to a wide variety of insecticides and fungicides.

The setup may also be adapted for running analyses out in the field.

Sorbic Acid as a Selective Agent in Cucumber Fermentations. I. Effect of Sorbic Acid on Micro-organisms Associated with Cucumber Fermentations

COSTILOW, R. N.; W. E. FERGUSON AND S. RAY

Applied Microbiol. 3: 341-345. 1955. (Journal Article 1777 from the Michigan Agricultural Experiment Station)

Extensive laboratory experiments demonstrated that 0.01 percent sorbic acid in an 8 percent salt (NaCl) medium at pH 4.0 would completely inhibit the growth of the yeasts most common to cucumber fermentations. Both surface and subsurface types of yeasts were tested. Conversely, this agent was found to have no appreciable effect on the growth and acid production of the species of lactic acid bacteria common to cucumber fermentations even at 0.1 percent concentration.

Both the pH and salt (NaCl) concentration were found to influence the effectiveness of sorbic acid as a yeast inhibitor. At pH 6.0, none of the major species were completely inhibited by 0.1 percent sorbic acid, while all species of yeasts tested failed to grow in this concentration at pH 5.0. Four times more of the acid was required to prevent growth of two of the yeasts tested in a salt-free medium than in an 8 percent salt medium.

A Study of the Acid-Forming Bacteria from Cucumber Fermentations in Michigan

COSTILOW, R. N.; F. M. COUGHLIN, D. L. ROBACH AND H. S. RAGHEB

Food Res. 21: 27-33. 1956. (Journal Article 1778 from the Michigan Agricultural Experiment Station)

During the 1953-54 cucumber brining seasons, a total of 848 cultures of acid-forming bacteria were isolated from 78 cucumber fermentations. This collection was screened and grouped and representative cultures from each group were studied in detail. On this basis, the cultures were identified as follows: *Pediococcus cerevisiae*, 284 (33.5 percent); *Lactobacillus plantarum* 333 (39.2 percent); *Lactobacillus brevis*, 188 (22.2 percent); and miscellaneous, 43 (5.1 percent). As to sequence, only *Pediococcus cerevisiae* was found to occur at a very definite time during the fermentation. More than 90 percent of the cultures of this species were isolated during the first 10 days after brining of the cucumbers. This species predominated during this period. The other three major groups were isolated from all stages of the fermentations studied — up to 40 days. The addition of 0.5 percent and 0.1 percent sorbic acid to cucumber fermentations had no significant influences on the types of lactic acid bacteria isolated.

Interactions Between Ascorbic Acid and Psychrophilic Bacteria Associated with the Discoloration of Prepackaged Beef

COSTILOW, R. N.; B. A. BATSHON, L. J. BRATZLER AND D. A. ROBACH

Food Tech. 9: 560-563. 1955. (Journal Article 1779 from the Michigan Agricultural Experiment Station)

Certain psychrophilic organisms are known to cause rapid discoloration of prepackaged meat. Conversely, ascorbic acid has been shown to delay discoloration of fresh packaged meat. Laboratory experiments showed that two strains of *Pseudomonas* sp. were inhibited greatly by 0.1 percent ascorbic acid in nutrient broth. This was true at both room and refrigeration temperatures. These same strains of *Pseudomonas* sp. protected the ascorbic acid *per se* from oxidation at room temperature, but had no significant effect on the concentration of total vitamin C-like compounds at either temperature of incubation.

The ascorbic acid was shown to delay discoloration of both inoculated and uninoculated steaks held at refrigeration temperatures for varying periods up to 24 hours. However, no effect of ascorbic acid on the growth of psychrophilic bacteria on the surface of prepackaged beef was noted.

Growth and Pectolytic Activity of Some Tomato Molds at Different pH Levels

RAGHEB, H. S., AND F. W. FABIAN

Food Res. 20: 614-625. 1955. (Journal Article 1780 from the Michigan Agricultural Experiment Station)

A total of 25 molds isolated from tomatoes, belonging to the genera *Aspergillus, Botrytis, Colletotrichum, Fusarium, Oospora, Penicillium, Rhizoctonia, Rhizopus*, and *Trichoderma* were examined for pectolytic activities and growth at different pH levels. The pectolytic activity was determined by viscosity measurements, and growth was determined by weighing the mold mats. The relationship between pH, pectolytic activity and mold growth was established.

Probit Analysis Applied to Salmonella Pullorum Survival Data

BATEN, W. D., AND H. J. STAFSETH

Jour. Bact. 71: 214-216. 1956. (Journal Article 1789 from the Michigan Agricultural Experiment Station)

This work was done to demonstrate how probit units may be used to obtain straight lines from which predicted 50 percent and 95 percent lethal times may be obtained. Data for this purpose were taken from a paper about *Salmonella pullorum* (Stafseth et al., 1952). These authors investigated the survival of S. *pullorum* on the skin of human beings and in eggs during storage and various methods of cooking.

Studies on Tenderness of Beef. II. Varying Storage Times and Conditions

PAUL, P. C., AND L. J. BRATZLER

Food Res. 20: 626-634. 1955. (Journal Article 1790 from the Michigan Agricultural Experiment Station)

Eight pairs of longissimus dorsi muscles from prime, good and commercial grade beef animals were used to study the effects of various cold storage and freezing and thawing treatments on cooking time, cooking losses, and shear tenderness of steaks fried in deep fat.

Significant differences in cooking time and losses were found among the various treatments. The high correlation between cooking time and losses indicated that one of the major factors affecting cooking loss was the time required to cook the steak.

The prime grade steaks were more tender than those from the good or commercial grades, although increase of cold storage time tended to minimize the grade difference.

As expected, increased length of cold storage increased the tenderness of the steaks. Any handling of the muscle, such as removal from the carcass before or during storage, or cutting of the muscle on the carcass, interfered with the tenderizing process, and resulted in less tender steaks than those aged in the normal manner on the carcass.

Additional cold storage or freezing of the steaks after 3 days of aging on the carcass increased the tenderness. Within the time studied (0, 1 or 2 days additional storage) cold storage was nearly as effective as freezing and thawing in increasing the tenderness. Frozen steaks cooked without thawing were less tender than those thawed before cooking.

In most of the muscles, the anterior and posterior portions differed in tenderness, the anterior being the more tender in the majority of cases. There was also considerable variation in individual steaks within each portion, suggesting the need for careful consideration in selecting samples for comparability when planning experiments.

Effects of Electromagnetic Energy on Plants and Animals

BAKER, V. H.; D. E. WIANT AND O. TABOADA

Ag. Eng. 36: 808-812. 1955. (Journal Article 1791 from the Michigan Agricultural Experiment Station)

The effect of electromagnetic energy of wave lengths of 2880 angstron or longer on biological tissue is essentially a heating effect; the effect of elec-

tromagnetic energy on wave lengths 2880 angstrons or shorter is mainly a chemical effect. There is no clear-cut line between the heating and chemical effect. There is some chemical effect on tissue at 2880 angstroms. As the wave length becomes shorter and shorter, the chemical effect becomes more pronounced and the heating effect becomes negligible.

The effects of ionizing photons of electromagnetic energy and the effect of subatomic particles on tissue are somewhat the same. In either case, the end result of the absorption of ionizing radiation is the production of ionizing particles. Tissue damage is caused by these particles.

Sorbic Acid as a Fungistatic Agent at Different pH Levels for Molds Isolated from Strawberries and Tomatoes

BENEKE, E. S., AND F. W. FABIAN

Food Tech. 9: 486-488. 1955. (Journal Article 1796 from the Michigan Agricultural Experiment Station)

Various fungi isolated from tomato and strawberry fruits were placed in a glucose-peptone medium with concentrations of sorbic acid ranging from 0.01 percent to 1.0 percent at pH 3, 5 and 7. These same fungi were also seeded in a strawberry puree at a pH of 3.3 and 4.0 with concentrations of sorbic acid of 0.025 percent, 0.050 and 0.075 percent. Some of the strains of *Penicillium, Alternaria* and *Aspergillus* showed slight growth at a pH of 4.0 in strawberry puree in 0.050 percent sorbic acid.

When tomato juice was used as the medium, all fungi except one strain of *Aspergillus* were inhibited at a pH of 4.4 in 0.050 percent sorbic acid. When 0.075 percent sorbic acid was added to the various media, no growth of the fungi occurred. Likewise, 0.075 percent sorbic acid inhibited the growth of all the test fungi when added to strawberry puree or tomato juice at a pH natural to these products.

The more important fungi causing rot in strawberry fruits, *Botrytis* and *Rhizopus,* were inhibited when 0.025 percent sorbic acid was put in the strawberry puree. A number of the more important fungi causing rot in tomato fruits such as *Colletotrichum, Fusarium, Rhizopus* and *Rhizoctonia* were also inhibited in the tomato juice by 0.025 percent sorbic acid.

Studies on Tenderness of Beef. III. Size of Shear Cores: End to End Variation in the Semimembranosus and Adductor

PAUL, P., AND L. J. BRATZLER

Food Res. 20: 635-638. 1955. (Journal Article 1798 from the Michigan Agricultural Experiment Station)

Steaks from the semimembranosus and adductor muscles of one prime grade and two good grade beef carcasses were used to study the effects of storage, muscles, and position within the muscle on cooking time, cooking losses and shear tenderness. A comparison was made of the use of ½-inch and 1-inch cores for the determination of shear force.

The close agreement in trend between shears from ½-inch and 1-inch cores suggest that either size may be used to measure shear tenderness. The adductor muscle proved to be quite uniform in shear tenderness, regardless of grade, treatment, or position of the steak in the muscle. On the other hand,

the shear tenderness of steaks from the semimembranosus muscle was affected by animal, grade, storage and position.

The steaks from the good grade animals became more tender between 6 and 9 days of storage, while those from the prime animal were less tender after 8 days of storage than after 6. The first and second steaks from the anterior portion of the muscle were more tender than the center portion, while the seventh, eighth and ninth steaks from the posterior portion were less tender. The 4-inch block of steaks, three through six, tended to be quite uniform in shear tenderness.

Valving Air Flow in Drying Bins

KAZARIAN, E. A., AND C. W. HALL

Ag. Eng. 36: 801-802. 1955. (Journal Article 1800 from the Michigan Agricultural Experiment Station)

An analysis of air flow in a grain bin of nonrectangular cross-section with a center main air duct is presented. With shallow depth, the air will pass vertically through the grain and ventilate the grain on the sides of the duct.

To obtain uniform air flow, valving is used in which paper is placed on the grain over the duct. As the depth of grain increases over the duct, less valving is required to obtain uniform air flow. For a 16-foot wide building, 172 inches of valving is required to obtain maximum uniformity of air flow for depth of grain less than 3 feet; 104 inches is needed for depth ranging from 3 to 6 feet, and 70 inches for depth of from 6 to 8 feet.

Welfare Implications of Efficiency and Technological Improvements (In Marketing Research and Extension)

WITT, L. W.

Jour. Farm Econ. 37: 912-923. 1955. (Journal Article 1803 from the Michigan Agricultural Experiment Station)

The general contribution of welfare economic theory to this problem was reviewed. Technological changes were separated into those which save farm products and those which do not. The former are less likely to benefit the farmer than the latter. Both benefit the consumer. It is more difficult to trace these effects in a dynamic society than in a more stable one.

Consideration was also given to these changes in relation to prices and the efficiency of a pricing system. Finally, six rules were presented to guide marketing research and extension which were believed to be in accordance with the basic goals and values of the American society.

The Use of Specific Gravity of Certain Untrimmed Pork Cuts as a Measure of Carcass Value

PEARSON, A. M.; L. J. BRATZLER, R. J. DEANS, J. F. PRICE, J. A. HOEFER, E. P. REINEKE AND R. W. LUECKE

Jour. Animal Sci. 15: 86-92. 1956. (Journal Article 1815 from the Michigan Agricultural Experiment Station)

Using 103 carcasses, the relationship between the specific gravity of three untrimmed pork cuts, i.e., the ham, loin and shoulder, with certain other

measures of carcass leanness were investigated. The somewhat higher relationship for specific gravity of a single ham to other measures of carcass leanness indicated that the untrimmed ham was a more reliable index of the entire carcass than either the rough loin or untrimmed shoulder.

Specific gravity of either the entire carcass or a single ham proved to be superior to backfat thickness as a measure of carcass leanness. Results indicated that both length of carcass and backfat thickness were better measures of leanness for hogs weighing less than 200 pounds than for heavier hogs.

Some Factors Affecting the Heat Stability and Viscosity of Half-and-Half Homogenized Milk

HUMBERT, E. S.; J. R. BRUNNER AND G. M. TROUT

Food Tech. 10: 134-137. 1956. (Journal Article 1819 from the Michigan Agricultural Experiment Station)

Processing and compositional factors affecting the viscosity and heat stability of half-and-half homogenized milk were studied.

The viscosity of half-and-half homogenized milk was increased by single-stage homogenization, especially at higher than normal pressures. Double-stage homogenization produced less increase in viscosity in similar samples. Effects of homogenization became more pronounced as the fat content of the sample was increased upward to that of light cream.

Generally, the heat-stability of the homogenized samples followed an inverse relationship, to that of viscosity. Other factors being approximately equal, the addition of nonfat dry milk resulted in a product of lower heat stability.

None of the fresh experimental samples could be induced to "feather" in coffee made with hard, "tap" water.

The inclusion of various increments of calcium in distilled-water coffee demonstrated that homogenization, especially single-stage processing, was conducive to the appearance of the "feathering" defect.

The addition of nonfat dry milk to the samples served as a "buffering" agent against the acid-precipitation of half-and-half homogenized milk.

Generally, increasing increments of added calcium resulted in a lowering of the acid-stability of the sample; whereas the addition of citrate resulted in an increase in the acid-stability. Magnesium had apparently little effect on the acid-stability.

A Comparison of Sampling Techniques Utilized in an Ecological Study of Aquatic Insects

GUYER, G., AND R. HUTSON

Jour. Econ. Entomol. 48: 662-665. 1955. (Journal Article 1834 from the Michigan Agricultural Experiment Station)

An estimation of the aquatic insect fauna of ponds was investigated by sampling the adult and immature insect populations. The principal taxonomic groups represented were the tribes Tendipedini and Calopsectrini, the subfamilies Pelopiinae and Hydrobaeninae of the family Tendipedidae, and the subfamily Chaoborinae of the family Culicidae. Tent and funnel traps were equally successful in making a quantitative and qualitative estimation of all

taxonomic groups sampled during the study, with the exception of the adults of the family Heleidae and the order Ephemeroptera.

When the adult and immature insect populations in a pond were sampled to the same degree, the emergence patterns of individual species and higher taxonomic groups could be predicted equally as well with the adult insect samples as with the conventional bottom deposit samples.

Tracer Technique Gages Raying of Irregular-Shape Foods

McARDLE, F. J., AND D. E. WIANT

Food Eng. 28: 85. 1956. (Journal Article 1841 from the Michigan Agricultural Experiment Station)

A simple method has been developed for indicating the distribution of radiation over the surface of irregularly shaped products. The technique is especially adapted to conveyor adjustment when the total surface of fruits and vegetables are being irradiated by cathode rays.

Plaster-of-Paris molds of the products are first prepared. Replicas of the products are then cast with agar-gel containing resazurin, an oxidation-reduction dye (10 ml. of a 0.1 percent aqueous dye solution per liter of 2 percent agar).

When the casta are irradiated, the dye is transformed from its natural blue color to red, then to a colorless state. Color change depends on the degree of ionization in the irradiated area. After treatment, there is a clear differentiation between exposed and unexposed areas which may be studied by dissecting the cast.

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